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ABSTRACT

A science education game, called "Challenge," was developed and tested. In a course designed to review the concepts that are useful in teaching elementary school science, one group of black graduate students used the game while a control group used the conventional lecture-discussion format. The game was designed to allow the player an opportunity to relate his knowledge of science to elementary classroom situations. A role-playing design was used to give the students practice in expressing scientific concepts using their own words. The results of analysis of variance comparisons indicated that the experimental gaming group had significantly superior posttest results in achievement in science, attitude toward science, confidence in science, and in the learning of the specific concepts that were taught in the game. It was found that individual personality and background characteristics could differentially predict the posttest measures and that low achievers in science benefited most from the gaming strategy. Their achievement posttest scores nearly matched those of the high achievement group. Thus, the learning game reduced differences in achievement that were detected on the pretest while raising the achievement mean for the entire group. (JY)

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TECH REPORT

A STUDY OF THE COGNITIVE AND AFFECTIVE OUTCOMES OF A COLLEGIATE SCIENCE LEARNING GAME

William L. Harvey

Tech Report No. 17
November 15, 1970

Project NR 154-280
Sponsored by
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The subjects were 78 teachers enrolled in two graduate level science education courses during the summer quarter, 1970. One class served as a control group, the other as the experimental group. Approximately half of the quarter was devoted to the review of science content. During this period the control

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The game is designed to allow the player the opportunity of relating his knowledge of science to the elementary classroom situation. A role playing design is used which gives concepts in their own words.

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The results suggest that a learning game of this type may be an effective agent in providing a learning environment that fosters growth in both the cognitive and affective domains.

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The subjects were 78 teachers enrolled in two graduate level science education courses during the summer quarter, 1970. One class served as a control group, the other as the experimental group. Approximately half of the quarter was devoted to the review of science content. During this period the control group used a traditional lecture-discussion approach, while the experimental group used a learning game.

The game is designed to allow the player the opportunity of relating his knowledge of science to the elementary classroom situation. A role playing design is used which gives concepts in their own words.

The results of analysis of variance comparisons indicated significantly superior posttest results in achievement in science, attitude

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CHAPTER I

STATEMENT OF THE PROBLEM

Background for the Study

A widespread disillusionment with traditional teaching methods seems to be a central theme in today's student unrest. Smith (1969) reports that at all levels of instruction, educators are discouraged by the apathy and listlessness of their students, and by the alarming number who dropout of the educational system. These dropouts often report that their school experiences seemed irrelevant to the issues and problems that they face.

The educational world must face the realization that tomorrow will be characterized by rapid change, by an explosion of knowledge, and by new technological developments that are likely to make much of what we learn in today's schools obsolete by the time it is applied. Marshall McLuhan (1964) suggests that the nature of consciousness is changing as a function of technology, and that the future generations may be so different that transmission of ideas between generations may be very difficult. Many educators are beginning to raise serious doubts about the value of present curricula, media, and presentation methodology in meeting the challenges of the future.

Raser (1969) points out that new goals for education are appearing which ask questions as: How do people learn? What will the future be like? What educational experiences should be provided

our youth to nourish these futuristic attributes? Raser contends that the mind is an instrument to be developed, not a bin to be filled. He further emphasizes engagement as a nucleus of educational experiences that result in "real" learning. Raser states that in the automated, cybernated world of the future the grasp of complex systems will be the most relevant skill and that the student must view the world as a dynamic process, not as a series of static events.

Objective of the Study

This study was conducted to determine the effect the playing of a science education game had on the cognitive and affective processes of black graduate students at Florida A & M University. A concurrent treatment group using a lecture-discussion format was used as the control.

The Use of Teaching Games as a Strategy of Instruction

Learning games have been cast in the role of achieving all of these new goals for education. Gaming is, in essence, a process of learning to learn. The literature is full of educators who advocate the use of academic games in the classroom--Brandes (1954), Carlson (1967), Darren (1967), Johnson (1960), Osgood (1957), Phillips (1967), Vivian (1963), Wagner (1959), and Wing (1968). The great majority of people who have played or administered learning games report that they create intense involvement and motivation. Learning games further focus on process and system behavior rather than on small details.

Alger (1963) surveyed the use of the Internation Simulation (INS) at the college level and provided the following list of claims for the gaming technique:

1. Simulation (or gaming) heightens the interest and motivation of students in several ways. It is stimulating, involving, provides a shared experience as a basis for later discussions, and is a catalytic agent, providing students with objectives for sharing background information.

2. Simulation offers an opportunity for applying and testing knowledge gained from reading and other experiences.

3. Participation (as a decision-maker, for example) gives the student insight, empathy, and a greater understanding of the world as seen and experienced by real decision-makers.

4. Most simulations provide a simplified "world" that is easier for the participant to comprehend as a whole than are the real institutions being represented (1963, p. 152).

An interesting characteristic of learning games is that they often can be played in an intellectually rewarding manner by students of varied backgrounds. Ten year olds and graduate students have played INS with equally satisfying results. Bruner (1960) has said:

> It can be demonstrated that fifth-grade children can play mathematical games with rules modeled on highly advanced mathematics; indeed they can arrive at these rules inductively and learn how to work with them (1960, p. 69).

Grade, age, and intellectual factors are thought to be much less critical in the play of a game, as contrasted with conventional materials. This approach thus can be thought of as a form of individualized instruction, much the same as self-study sequences or computer-assisted problem solving. Wing (1968) creator of two games in which a computer provides the environment within which the student plays a role, argues that individualization is a key factor in the success of a game. Studies of the type conducted in this investigation

are indicated to determine the type of individual that benefits from the learning game and under what conditions.

Boocock and Schild (1968) view games as a possible bridge to span the learning gap between the unsuccessful student and his more successful peers. They include the underachiever, the nonmotivated, the culturally deprived, the inner city, and various other types of problem students in this category. They point out most innovations in teaching have been unable to close the gap; on the contrary, they often provide the able student with additional tools with which he can move even further ahead of his peers. Blaxall (1965) gives instances of learning break-throughs, when a previously withdrawn, unresponsive, non-achieving, or trouble-making student comes alive in a gaming session and proves himself surprisingly active and effective in planning strategy. Boocock (1968), Inbar (1965), and Cohen (1964) report empirical evidence that appears to show that the relationship between learning in a game situation and performance in the conventional school setting is very weak. Thus games may provide a different way of learning and in combination with conventional methods may decrease the variance of achievement (without decreasing the mean).

The population of this investigation contained a large number of black teachers that were under-achievers in the sciences. Pettigrew (1964) offers a reason why these under-achievers may do well in the gaming environment. He has shown that unsuccessful students may accept the role of failure and develop a psychological set which makes them continue to do poorly. The game may break this set and thus the obligation to fail. Rotter (1966), Seeman (1963), and Coleman (1966) report evidence that supports the view that behavior in general and learning in

particular is strongly affected by the individual's sense of control of his own destiny. Bruner (1966) describes below the possible long-term benefits that a series of games may have on a person's outlook towards life:

> . . . first of all an attitude in which the child learns that the outcomes of various activities are not as extreme as he either hoped or feared . . . . In time, the attitude of play is converted into what may best be called a game attitude, in which the child gets a sense not only that consequences are limited but that the limitations come by virtue of rules that govern a procedure, whether it be checkers or arithmetic, or baseball (1966, p. 134-145).

The Evolution of Play and Games

Play, according to Piaget (1967), is an imaginary imitative activity that serves as a primary socializing influence on children. Play becomes a game when formal rules or constraints are added and a system of rewards or payoffs is present. Learning games are a modern hybrid used by educators to motivate students and instill desired behaviors.

Huizinga (1950) in his classic book "Homo Ludens" describes man as a playing animal. He suggests that play is a type of self-conceived activity that needs little outside justification for its existence. Play is thus its own reward in this theory. He goes on to speculate that nearly all man's activities are related to play. Man has, according to his reasoning, forgotten that we are just playing somewhere in his evolution and is desperately searching for meaning in daily events, many which have no significance other than their own existence. Berne (1964) in his book "Games People Play" also develops a theory of play, but much different from that of Huizinga's. Berne refers to the destructive manipulation of self and others as the games

we play. People play these games because of their inability or unwillingness to face life in a mature manner. These contrasting notions of play serve to illustrate the idea that the concept has many dimensions. A single theory of play or gaming is thus likely to be a gross oversimplification.

Most experts trace the beginning of formal games and simulations to the war games. Chess is an example of this type of game that was probably designed by noblemen to entertain themselves while brushing up on their military strategy. Raser (1969) points out that the more sophisticated modern games owe their potency to the techniques derived from small-group experimentation, decision theory, and systems analysis.

Raser (1969) makes the observation that the terms simulation and game have often been used interchangeably in the literature. He feels the following distinction should be made:

> The more explicit is the "operating model," that is, the greater the extent to which all the seemingly salient variables are formally preprogrammed and the more it is believed that the model is a complete and accurate analogue to some "referent" system, the more likely it is that the model will be called a simulation. On the other hand, the more informal and tentative the model and the more it relies on human participation as an intrinsic component in its operation, the more likely it will be called a game (1969, p. x).

Huizinga's definition of a game describes its more general aspects when he describes it as:

> A voluntary activity or occupation executed within certain fixed limits of time and place, according to rules freely accepted but absolutely binding, having its aim in itself and accompanied by a feeling of tension, joy, and consciousness that is different from ordinary life (1950, p. 28).

With a distinction made between a simulation and a game, there still remains the task of relating game theory to the scheme. This has been done skillfully by Brody (1963):

> The Theory of Games ("Game Theory") provides a means of describing the strategic behavior of one or more actors who have to make choices in conflict situations (games) in which the payoffs (potential outcomes) are a function of the choices made by all parties to the conflict. The Game Theory model is normative, in that it prescribes the choice or combination of choices which lead to the best payoff under the circumstances of a given conflict situation. The theory, moreover, postulates a "rational" actor who will always follow this best strategy. A political game (or simulation) is an operating model which represents an attempt on the part of the theorist, through the representation of an empirical system to provide himself with information about real states of the system (1963, p. 211-212).

From the above clarifications it can be seen that Game Theory is a set of mathematical tools for dealing with discrete types of conflict situations. Learning games and simulations, in contrast, are attempts by theorists to fabricate operational models of physical and social systems.

Abt (1969), a pioneer in the field of gaming, distinguishes three types of formal games:

1. showdown-where each player exhibits his best physical or mental performance and luck without interference from any other player, and the results are compared
2. strategy-in which opposed players interfere with each other
3. combination-games incorporating strategies exchanges preliminary to showdowns

Educational games may take any of the above forms. Chance is typically used to simulate uncertainty in the referent system. Abt (1969, p. 77) states that educational games may also be classified as skill, chance, reality, or fantasy depending on the game's emphasis. In games of skill the winner is said to be determined by his relative capabilities.

Skill games tend to reward achievement and individual initiative. It is also pointed out that they may have a negative value in that they may discourage slow learners and show up their inequalities. In games of chance Abt (1969) states that the player's capabilities have no bearing on the outcome. He does say that they have an educational value since they may show the limitations of effort and skill. This may have the effect of humbling the overachievers and encouraging the underachievers. Chance games are said to be most popular with slum populations, most of which are probably underachievers. Chance games also have the negative effects of encouraging magical thinking and passivity. Abt (1969, p. 77) says that reality games are really simulations of real world operations. They teach the student structural relationships and exploit the student's craving for adult reality. Abt (1969, p. 77) makes the statement that these games may tend to make students over impressed with the predictability of events. Fantasy games are the last classification used by Abt and include activities like dancing and skiing which give emotional uplift and stimulate the imagination, but are low in cognitive value.

This investigator has observed that educators usually construct reality games of the strategic type. This is a result of their value system and not due to the range of possibilities of the gaming technique.

Boocock and Schild (1968) feel that learning games for classroom use have gone through three distinct stages of development. The first phase they call acceptance on faith. During this period social scientists were said to have discovered gaming as an innovative experience for the classroom. Many games were designed and field tested

during this period of enthusiasm. This phase was said to end about 1963 and it did not produce much hard evidence to support the claims for the technique. The second phase, post-honeymoon, ran from 1963-1965 and was characterized by researchers attempting to conduct controlled experiments with games. Boocock and Schild describe the results of these experiments, generally inconclusive, as a sobering experience for researchers. The reality that contemporary games had many flaws and were not a panacea for education became known. These scientists also reported that present measurement tools were not adequate to measure the impact of games.

Two general attitudes soon developed concerning the direction learning game research should follow. Thorelli and Graves (1964) represented one group that felt the working hypothesis that games do teach should be maintained. Cherryhold (1966) recommended, however a retreat from the original hypothesis that games can teach better than conventional materials. He sees the technique as more of a motivational device for change of attitudes.

Boocock and Schild call the third phase realistic optimism. It began in 1965 and extends to date. During this period games were field tested in a wide variety of educational settings and a pool of data concerning learning effects was gathered. From these findings came a more justified optimism, according to these authors.

Research on the Effects of Learning Games

While a number of educators have claimed beneficial results from the use of games, there is a scarcity of experimental research to confirm their feelings. Burgess (1969) conducted a study using games

as a strategy to improve the learning of mathematics and the attitudes toward mathematics of low achieving secondary students. Employing a control group which used paper and pencil materials, Burgess reports a significant difference in favor of the game group on attitudinal measures, but did not find statistical superiority in achievement. Certain parts of the achievement measure favored the experimental and other parts the control groups, which led the investigator to speculate that some of his games were more effective than others. Burgess further advanced the idea that games may be more appropriate for certain types of conceptual learning.

Allen (1968) used a logic-symbol game to build problem solving ability in a class of summer school students. He used a pretest and posttest design with scores on the California Test of Mental Maturity as the criterion. He used a group of students from the following regular school year as his control. The results, based on the difference scores, indicated a much more favorable change on the part of the game group. Allen concluded that his game had indeed significantly enhanced the problem solving ability of the class. Campbell and Stanley (1966) have pointed out that designs of this kind often introduce differences in maturation, history, and selection and might not in these cases represent real treatment effects.

Wing (1968) used two computer-based games (Sumerian and Sierra Leone Game) to teach economics to sixth grade students. Reporting that sixth graders were capable of progressing through the program with little assistance, Wing also states that pupil interest was high for the usual fifteen hours of instruction. Using a pretest and posttest

design with concurrent control and experimental groups, Wing (1968) concludes with respect to learning:

> Although the only statistically significant difference is the one pertaining to the larger gain of the experimental group in respect to the Sumerian Game, the total of the data seem to impose a cautious conclusion; that no difference in amount of learning was demonstrated. Insofar as these data go, no claim to superiority can be made either by the computer game technique or by the conventional classroom method of instruction (1968, p. 161).

We have a different result when we compare time invested per pupil on instruction. The experimental group used about one half the time expended by the control. So the computer game was judged more efficient.

Two studies by Humphrey (1965 and 1966) used games to teach language skills and number concepts to primary aged students. In the first, Humphrey used workwork exercises as the alternate treatment to teaching language skills. This investigator reports that the active game medium produced greater changes, but not at a significant level. In the second experiment Humphrey used a game with first grade children to teach number concepts. He used a pretest-posttest design without a control group. He reports the median score rose sufficiently to indicate a significant difference ($p < .001$). Without the control group all that can be said is that it appears that the children acquired number concepts by playing games.

Boocock (1968) conducted two games which simulated real life situations at a 4-H convention. She assigned the students to two groups in a random manner. One group played the Legislative Game, and the other the Life Career Game. A questionnaire was administered before and after the gaming sessions. The questionnaires were fashioned in such a way that each group served as a control for the other. Boocock did not find many significant differences in her data

She found evidence that factual learning resulted from playing the Life Career Game and there was a tendency toward a liberalization of attitudes toward politics after playing the Legislative Game. She comments:

> The over-all impression one gets from this experiment is that a good deal of learning can occur in simulation games of this sort and the experiment supports a basic tenet of the philosophy of educational gaming, that students can have fun and learn at the same time (1968, p. 87).

Baker (1968) also conducted a study that compared achievement in American history between two of his classes, one taught by gaming and the other by a text. The classes were said to be matched at the start of the study. After fifteen class periods he gave both groups an achievement test, and found that the group scores of the gaming class were significantly higher. He also reports a significant increase ($p < .01$) on an attitude score for the gaming group. Details of the administration of the experiment were not given and it is difficult for the reader to appraise the generalizability of the investigation.

The need for research into the effect of games

From the above studies no conclusive trend can be found that indicates that games do indeed teach intellectual and content skills in a diversity of applications. It is a plausible hypothesis that the characteristics of the learner and the content to be learned may play a significant role in the effectiveness of a game. The characteristics of the game itself may also be a critical factor. Many educators have speculated that the ultimate application of games will be their adoption as one of many approaches coordinated in an instructional system.

For this day to arrive much research will be required that determines the role of games in the learning environment. Boocock (1968) summarizes this need when she states:

> One of the major unsolved (though researched) issues in the field of simulation gaming concerns the type and effectiveness of the learning produced. While most researchers are agreed on the power of such games to interest and motivate students, there is disagreement over whether games also teach intellectual content and skills (1968, p. 107).

The Proposed Study

Purpose of the study

As indicated by the research literature there is a definite need for more research into the effects of games in different instructional settings. One setting that has not been investigated is that of graduate training of black elementary school teachers. Given the many learning problems for this group, there is a need for fresh strategies of instruction that promotes the learning of scientific concepts and at the same time improves the black teacher's attitude towards the nature and process of science instruction in the elementary school.

The purpose of this study was to determine the extent to which the playing of a science education game could promote cognitive and affective objectives. The game in this context thus replaces the conventional lecture-discussion method.

Research hypotheses

The study was concerned with four dimensions or effects of the use of a teaching game in a graduate level science education class. These effects may be briefly described as changes in attitude toward

science, general confidence in mastery of science, general achievement in science, and the mastery of specific scientific concepts taught in the game. An additional consideration for the study was the differential effect of background and personality variables to the success of students in the two treatment groups (gaming and lecture-discussion).

Many of the above studies have reported attitude changes related to the playing of games. Few of the studies, however, used adults and their attitudinal structure may be more fixed or rigid than youngsters. The investigator has observed that an elementary teacher's attitude towards science may determine the quality and quantity of science instruction found in her classroom. The first research hypothesis was thus designed to test the effect of changes of attitude toward science in the two treatment groups.

General confidence in science is the second area of interest in this study. General confidence, as used in this study, describes a feeling of security or comfort in one's knowledge and skill in a specified domain. It is conjectured that teachers who feel uncertain about their grasp of science are likely to teach the subject in an incidental manner in the classroom. It is possible that through the vehicle of a game this feeling of general confidence in science may be developed. This dimension of gaming has not been investigated in prior research and is an important research hypothesis for this study.

Growth in general science achievement is the third outcome that this study investigated. If games produce the motivation that has been reported in the literature, they should serve to stimulate students to perform their out-of-class activities in an inspired manner.

this interest and attention should serve to increase the student's general achievement in the sciences.

It is possible that the playing of a game may be a very effective device for focusing attention on a concept and thus make it more likely that the concept will be mastered. Thus the game may teach directly and not be simply a motivational device. The fourth research hypothesis was designed to test this effect of a teaching game.

It is a plausible hypothesis that not all students will be equally motivated or instructed by a game (e.g. students with high or low achievement in science may react to the game differently). Traditional techniques may prove more efficient for certain types of students. The design of this study included the collection of background and personality variables which were used to identify possible types of persons that benefited from each treatment. The Omnibus Personality Inventory (OPI) isolates the personality variables. Social extroversion (SE), one of the scales on the OPI, might for example be a characteristic of persons that benefit from the freedom of the gaming environment. Students scoring high on the practical outlook (PO) factor may find the game of immediate utility and also do better in the gaming treatment. In this way the fifth hypothesis states that a differential pattern can be identified that predicts success for the two treatments.

The five questions investigated with black graduate students can be expressed as the following research hypotheses:

1. The regular use of a science education game as a teaching strategy with students results in a measurable improvement in their attitude toward science, as compared to students taught with lecture-discussion techniques.

2. The use of a science education game with students will result in a measurable difference in their general confidence in mastery of science concepts as compared with students taught by lecture-discussion.

3. The regular use of a science education game as a teaching strategy with students results in a measurable improvement in their general science achievement as compared to students taught with lecuture-discussion techniques.

4. The use of a science education game with students will result in a measurable difference in their mastery of specific science concepts (taught in the game) as compared with students taught with lecture-discussion techniques.

5. Background and personality variables will be differentially useful in predicting success in the two treatments (games and lecture-discussion).

Relation question

Although the study addressed itself to the research hypotheses proper, it was felt that as much additional information as possible should be gathered in order to determine peripheral effects or results. The following was considered in the course of designing the study:

> Is there any measurable relationship between attitude toward the science learning game and total game score and a student's attitude toward science, general confidence in science, general achievement in science, or mastery of specific concepts taught in the game?

The study was designed to attempt to answer the above research hypotheses and related questions concerning attitude toward science, general confidence in science, general achievement in science, and mastery of concepts taught by the game. The study further was concerned with the differential effect of background and personality variables in the success of students in the two treatments.

CHAPTER II

SELECTION AND PREPARATION OF THE MATERIALS

The purpose of the study was to investigate the effect of playing a science education game as a regular part of the instructional strategy of a graduate level science education course. To perform this investigation it was first necessary to construct an adequate science education game. This task required extensive field testing and revision of the game prior to its use in this study.

The second task was to locate or construct adequate measurement instruments to assess the effect of the game. No satisfactory science achievement test could be located commercially that was appropriate for elementary school teachers. A general achievement measure was thus constructed for this study that included a sample of scientific concepts frequently encountered in the teaching of elementary school science. Incorporated in this measure was an attitude and background questionnaire. Further, an additional measure required was one that assessed the mastery of specific scientific concepts taught in the game. This criterion test was included to measure the specific learning effect of the game. The Omnibus Personality Inventory (OPI) was selected to measure personality variables that might be useful in prediction of success for the two treatment groups. Finally, a gaming questionnaire was selected to measure attitudes toward the game.

This chapter will describe the procedures that were used to select and construct the above instruments.

Description of the Text

The text used by both the experimental and control groups was "Elementary School Science and How to Teach It" by Blough and Schwartz (1969). This text and its previous editions had been used for a number of years at Florida A & M University and previous instructors have reported satisfactory results. The primary function of the text was to provide the student with a review of the concepts that are useful in teaching science in the elementary school. In the traditional setting students first read an assignment in the text and this was followed by a lecture-discussion session in class. In the experimental group the same text assignments were made, but they were followed up in class with a game related to the materials rather than the lecture-discussion.

Development and Description of the Learning Game, "Challenge"

The episodes were designed to review major concepts and principles covered in the textbook assignments. The experimental group used games to replace the lecture-discussion coverage of scientific content used by the traditional control group. Students of both treatments thus were exposed to similiar topics, but the treatments differed in instructional strategy.

The research on learning games does not offer a set of procedures, that when met, insure a game is capable of effective instruction. Indeed, such a list might by necessity be too general to be

useful. What makes a game effective for one population might be ineffective for another.

Adair (1970) states that without a tested model for game design, the researcher must reason through the factors that are important to be included in a game designed for his population. The primary objective of the game constructed for this study was its relevance to actual classroom instruction. Teachers often complain that their collegiate work bears little relationship to actual teaching. It was felt that this relevance would increase the student's interest in the activity and focus more attention on the concepts under consideration. A related objective of the game was to increase the student's motivation toward outside reading in the areas covered in the game.

The game of "Challenge" is thus designed to allow the player the opportunity of relating his knowledge of science to the elementary classroom situation. A role playing design is used which gives the students practice expressing scientific concepts in their own words. Collegiate students often complain that they know the concept, but cannot put it into words.

The game is divided into four to six episodes (depending on the length of the chapter under consideration). An episode begins with a classroom experience that briefly describes the activities taking place in a hypothetical classroom. An episode required two characteristics to be included in the game. First, it had to be believable or typical of science activities in elementary schools. Second, it had to effectively focus attention on the scientific concept under consideration. Associated with each episode is a student question that

might plausibly arise and which is also central to the concept under consideration. An example of a typical classroom experience and student question follows:

> Classroom experience: The class is working on a unit on man's progress to the moon. One of the students brought a magazine article which discusses the problems that astronauts will face on the moon. One of the major problems was weighing only 1/6 as much as they do on the earth. A 180 pound astronaut would weight only 30 pounds on the moon.
>
> Question: The question was raised why a person's weight should vary on the moon (from that on the earth) and if this might have something to do with the moon lacking an atmosphere?

Three roles are assumed by all players in rotation throughout the game. These are the roles of judge, teacher, and pupil (challenger or acceptor).

The judge must perform three tasks to fulfill his role. First, he must read, at the appropriate time, the classroom experience, student question, and acceptable answer that appears on the episode card. Next, he must judge answers given by students playing the role of teacher. These answers are accepted or rejected depending on whether they are scientifically correct and adequately answer the question. The final function of the judge is to record all players scores on the game score sheet.

The role of teacher is assumed by each participant in rotation when he or she answers the student question that appears in the episode. The teacher may bluff an answer when she is unfamiliar with the area under consideration. When caught in a bluff, however, the teacher loses scoring points. This aspect of the game simulates the temptation placed on a real teacher when a question is asked by a member of the class that is outside the teacher's level of knowledge.

The third role is that of pupil. This role is played by all members of the gaming group, except the judge and teacher. When an answer is given by the teacher the pupils must either accept or challenge the answer. This stimulates a real student's acceptance or reservation concerning a teacher's response to a classroom question.

The procedures or steps that follow were used for playing the science education game:

1. The materials required for the play of the game were first distributed (3-6 players may play the game, with 5 being ideal):
   <u>each player receives</u>
   a. challenge and accept cards
   b. three wagering cards bearing 5, 15, & 25
   <u>each game group receives</u>
   a. game score sheet
   b. episode cards
   c. game starting cards

2. Each player first draws one of the start cards that has been placed blank side up on the table. The individual drawing the card with the highest number is designated the first judge.

3. The judge for this episode first fills in the players names on the game score sheet. He then opens the first episode card and reads the classroom experience to the group.

4. After the classroom experience has been read, each player must decide how many points he or she wishes to wager on the episode (5, 15, or 25 points). This choice is made by placing the appropriately numbered card face down. The judge does not wager in an episode.

5. The judge next reads the student question. The person to the right of the judge is given the first opportunity to give an appropriate reply to the question. An appropriate reply is one that answers the key elements of the question without giving any incorrect information. The player has the option of passing to the person on his right. If he does pass, 5 points are subtracted from his score for that episode. The turn continues to pass to the right until a player decides to play the role of the teacher and answer the question. If none of the players chose to answer, the judge receives 25 points added to his score. This is the only manner in which the judge can accumulate points during an episode.

6. If an answer is offerred by a participant, each subsequent player (except the judge and person answering) must decide whether the answer is appropriate for the question. Again, the relevance and accuracy of the answer is weighed. When the decision is made the player places the challenge or accept card face up in front of him.

7. The judge next reads the answer appearing on the episode card and makes the decision as to whether the answer given by the player is adequate. An answer is judged correct if it generally conforms to the answer on the episode card and does not introduce incorrect information. The decision of the judge is not debatable by the group until the scores are recorded.

8. The player answering the question first turns over the card that represents the number of points he had chosen to wager. If he was correct in his answer he receives two times that number of points added to his score. If he was incorrect and challenged by another player, he receives two times the number of points he wagered subtracted from his score. If he was incorrect, but not challenged by another player, he receives the number of points he wagered added to his score. This is a reward for a successful bluff. Each of the other players turn up their wagering and challenge or accept cards. If they are in phase and accept a correct answer or challenge an incorrect answer, they receive the number of points they wagered added to their score. If they are out of the correct sequence, they subtract the number of points wagered from their score.

9. The judge is responsible for recording all points won or lost during the episode. When all points have been recorded the person to the right of the judge becomes the new judge for the next episode. The game continues in a like manner for 4-6 episodes. The player with the highest number of points at the completion of the gaming session is declared the winner.

The following flow diagram in Figure 1 describes the pattern of the game:

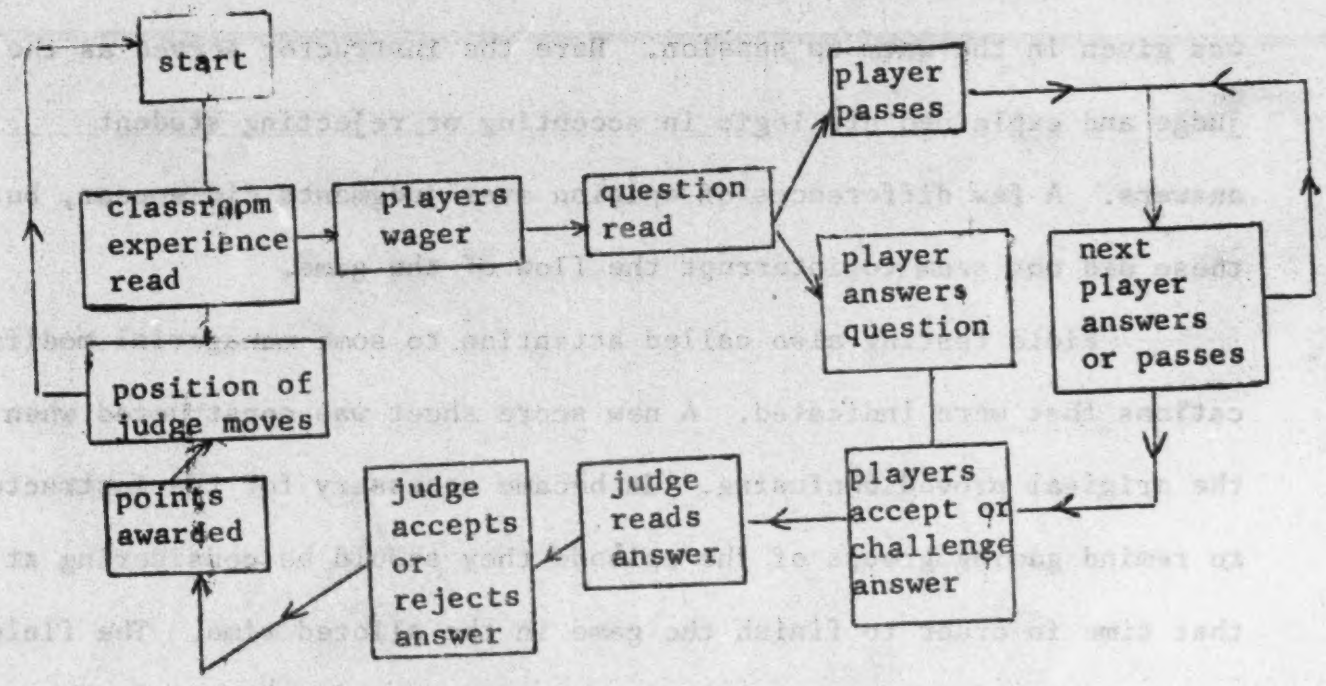

Fig. 1.--Flow diagram of the game.

The design of the game went through revision after field testing in the Spring of 1969. Unnecessary complexity and ambiguity was removed. Episodes that did not hold the players interest were rewritten or replaced. Wagering rules were also changed when it was discovered that the scope of strategies was reduced by the original payoff schedule. The original payoff schedule did not give double points for the person playing the role of the teacher. It also did not give points for a successful bluff. This revision made the game more interesting and instructive to the players.

The field testing also pointed out that the judge's role must be more rigidly defined than first thought necessary. The criteria for accepting or rejecting a player's answer must be uniformly applied if the game is to run smoothly. As stated previously, the criteria were giving an answer that is scientifically accurate and one that adequately

answers the question. Training in the application of these criteria was given in the warm-up session. Here the instructor served as the judge and explained his logic in accepting or rejecting student answers. A few differences of opinion over judgments did appear, but these did not seem to interrupt the flow of the game.

Field testing also called attention to some managerial modifications that were indicated. A new score sheet was constructed when the original proved confusing. It became necessary for the instructor to remind gaming groups of the episode they should be considering at that time in order to finish the game in the alloted time. The field experience also suggested that the constitution of the groups should be changed at regular intervals. Groups remaining together too long often slowed down and became less productive.

The field testing of the game of "Challenge" was thus judged vital in conducting an experimental study of this type.

Development and Description of the Background and General Achievement Measure

The background and general achievement measure was designed to serve three purposes. First, to collect relevant background and attitudinal measures. Second, to measure the student's current achievement in science content appropriate for elementary school. Finally, to measure the student's confidence in this science content. The general background and attitudinal measures collected were:

Background measures

1. sex
2. high school and college grade point averages
3. size of high school attended
4. science and mathematics courses taken
5. geographical location of student's high school

Attitudinal measures

1. general attitudes towards science
2. grade level preferred for teaching
3. estimation of importance of science in the elementary school
4. feelings towards science laboratory
5. attitude towards high school science teachers
6. preferred strategy for teaching science
7. reaction to new innovations in the classroom

This background and attitudinal data served to help describe the characteristics of the population used in the study. It served as the general achievement measure for the comparison of the gaming and lecture-discussion treatments. It further attempted to isolate variables that might be important in the prediction of success for students in the two treatment groups.

The general science achievement section of this measure was divided into four parts; life sciences, physical sciences, chemical sciences, and earth sciences. Twenty multiple choice questions were selected for each area. The major concepts considered in elementary science textbooks were listed and paired with appropriate questions. These multiple choice questions were selected and modified from the outline book "General Sciences" by Mould and Giffner (1959). This selection was made prior to construction of the learning game.

One of the major research hypotheses defined was concerned with changes in confidence, related to mastery of scientific concepts, between the two treatment groups. Many terms have been used in the literature to describe confidence (response uncertainty, subjective certainty, subjective probability, expectation of success) but their basic methodology is very similar. Typically, the investigator asks students to choose between two or more stimuli and to state the confidence with which he makes the choice. This type is described as

specific confidence in this study. Definette (1965) and Shuford (1966) have used this student confidence rating as a method of discriminating levels of partial knowledge concerning a test item and the relationship between these ratings and performance. Ford and Novick (1968) state that these methods are conceptually attractive, but empirical evidence as to their usefullness is lacking.

This investigation used confidence in a much broader manner. The term general confidence is used to describe a state of security or insecurity in a defined area, like the life sciences. This general confidence can be thought of as representing an array of specific confidences covering the content of the area. A group of general confidences combine to form a global confidence, which is called total general confidence in this study.

In this investigation a specific confidence measure is taken after each test item on the achievement and criterion tests. The total of these specific confidences is hypothesized to be an approximation of the general confidence in the area. The total of the general confidence is hypothesized to be an approximation of the global confidence. A measure was included in the achievement test to measure directly this general confidence and also the total general confidence or global confidence in an area.

On the achievement portion of the test the student was first asked to rate his total general confidence (global confidence) in science content that is appropriate for the elementary school. A five category scale was used covering the range from "I am very poorly prepared" to "I feel very well prepared." One of the four areas of science is next identified and its major content is listed. The student next

rates his general confidence in the area. Ten easy to medium multiple choice questions follow. The student also rates his specific confidence on each of these items. After the first ten items, the student again rates himself as to his general confidence in the specific area of science currently being tested. Next appeared ten medium to hard questions. After the entire set of twenty questions have been completed a general confidence measure is again administered for the area. The other three areas of science are tested in a like manner and after the last, a total general confidence measure (global confidence) for general science is again taken. The following measures are examples of the three types.

1. <u>An example of total general or global confidence</u>

   Which of the following statements best describes your knowledge of the general science content that is appropriate for elementary school
   a. I am very poorly prepared
   b. I know a little about some of the areas of science
   c. I know something about most of the areas of science
   d. I have a pretty good knowledge of most of the areas of science
   e. I feel very well prepared

2. <u>An example of general confidence</u>

   Which of the following statements best describes your knowledge of the areas of the life sciences that are appropriate for elementary school
   a. I am very poorly prepared
   b. I know a little about some of the areas of science
   c. I know something about most of the areas of science
   d. I have a pretty good knowledge of most of the areas of science
   e. I feel very well prepared

3. An example of a specific confidence

One difference between plants and animals is that only plants contain (a) carbon (b) oxygen (c) cellulose (d) living matter

Your confidence measure for this problem
a. I guessed at the answer
b. I knew a little about the question, but I am probably wrong
c. I am half-way sure my answer is correct
d. I am fairly sure my answer is correct
e. I am sure my answer is correct

The test requires approximately three quarters of an hour for administration. The responses to the measure are recorded on a special answer sheet. KR_{20} reliability measures for the control group (sample of 37) were .83 with a mean of 46.6 on the pretest and .85 with a mean of 49.1 on the posttest. The experimental group (sample of 39) had KR_{20} reliabilities of .79 with a mean of 45.9 on the pretest and .83 with a mean of 57.7 on the posttest.

Development and Description of the Criterion Measure

In addition to the general achievement test a measure was desired that would appraise the student's mastery of the concepts taught by the gaming episodes. To fullfill this requirement a measure consisting of 72 multiple choice questions was constructed. Each of these questions was directly related to one of the 72 concepts taught in the gaming sequence. Again, a 5-step specific confidence scale was administered after each question. The criterion measure averaged three quarters of an hour for administration. KR_{20} reliability measures for the control group (sample of 37) were .76 on the pretest and .84 on the post test. The experimental group (sample 39) had KR_{20} reliabilities of .68 on the pretest and .77 on the posttest.

Description of the Omnibus Personality Inventory (OPI) Form Fy

The Omnibus Personality Inventory was included in the testing program to estimate personality variables that might be related to performance on the achievement and criterion measures. The test contained 390 items and required about three quarters of an hour for administration. The measure identified the following categories:

1. thinking introversion (TI)
2. theoretical orientation (TO)
3. estheticism (ES)
4. complexity (CO)
5. autonomy (AU)
6. religious orientation (RO)
7. social extroversion (SE)
8. impulsive expression (IE)
9. personal integration (PI)
10. anxiety level (AL)
11. altruism (AM)
12. practical outlook (PO)
13. masculinity-femininity (MF)
14. response bias (RB)

The Omnibus Personality Inventory (OPI) was revised over a period of ten years to serve as one of the prime instruments for research on college students. This new personality inventory was developed under the auspices of the Center for Research and Development in Higher Education at Berkeley, California. The instrument was designed to provide a set of psychological dimensions which are especially relevant to describing and understanding important aspects of students' lives and behavior in an academic context. Heist (1968) describes the assessment approach used on the inventory in the following discussion:

> The chief approach to assessment in an inventory of this type is based on the assumptions that all or most persons in a particular society or culture acquire or develop a number of psychological characteristics in common, but that the diversity of genetic contributors and environmental experiences lead to great variation

> in the development of these characteristics. Since this is the case, it is also assumed that scales (measuring devices) can be constructed, with satisfactory validity, to tap the different degrees to which a characteristic exists. The measured characteristics, sometimes referred to as personality dimensions, are represented in ways or styles of thinking, in general orientations to things, events or persons in the environment, in feelings or emotional expressions, and in perceptions about oneself (1968, pp. 218-219).

These personality dimensions are verbally expressed in the form of opinions, preferences, interests, and attitudinal statements to which the student is asked to respond, indicating whether the statement describes himself or not. A scale is composed of a collection of these true and false responses in the same area. The number of statements in the selected direction serves as a measure of the intensity to which the characteristic exists in comparison with the average score obtained on a large, representative sample of students. These scale scores thus represent a relative and not an absolute measurement.

The OPI-Fy measure has been available commercially for a little over one year and a half. Investigations using the OPI scales are beginning to appear in the literature. The designers of this instrument were keenly interested in the assessment of creativity and many of these scales have been related to this factor.

Medsker (1967) used the OPI scales in a study of dropouts from college programs. He combined the scales of the OPI into a scale called "Intellectual disposition of the student." High scores are obtained, according to the investigator, by those students inclined towards abstract, reflective thinking, intellectual inquiry, and artistic experience. He found attenders of college to score higher on this combined scale than college dropouts.

In a study at MIT, Snyder (1968) attempted to determine the relationship between creativity and the tendency to drop out of college. He used three scales; thinking introversion, complexity, and implusive expression, as indicators of creativity. He found that students who scored high on the three scales of the OPI were more likely to leave MIT, than were students who scored low on these scales.

Treant and Medsker (1967) reported a multi-faceted longitudinal study of 10,000 high school graduates who were attenders and non-attenders of college. The OPI was administered to isolate personality factors that might differentiate the groups. He found significant differences between the groups for both men and women on the OPI scales which measured inclination towards reflection, abstract thinking, independence, and flexibility (the thinking introversion, non-authoritarianism, and social maturity scales of the OPI). There were no significant differences between groups in the measured extent of their intellectual curiosity or tolerance for ambiguity (the complexity scale of the OPI).

A longitudinal study is also reported by Korn (1968) which used an early form of the OPI to chart differences in personality factors of Stanford and Berkeley students from their freshmen to senior years. Korn used six scales of the OPI (Social Maturity (SM), Impulse Expression (IE), Schizoid Functioning (SF), Masculinity-Femininity (MF), Estheticism (ES), and Developmental Status (DS) to measure this possible change. He reported that there was a consistent pattern of change among both Stanford and Berkeley students over the four undergraduate years. The significant differences found were said to reflect

a movement toward greater openmindedness and tolerance, a rejection of a restrictive view of life, and a humanization of conscience.

Majer (1969) used the OPI as a predictor variable to differentiate performance between two treatment groups. The experimental group was a Computer Assisted Instruction/media course with an added discussion group. The control was the same course taught by the traditional lecture method. The OPI scales of Religious Orientation (RO), Masculinity-Femininity (MF), Altruism (AL), Response Biase (RB), Theoretical Orientation (TO), and Impulse Expression (IE) were used as predictors of final examination score for the course. This study demonstrated that the OPI scales can be predictors of success for academic achievement.

Form F is the latest version of the OPI. Earlier forms are reported in Buros (1965). Validity and reliability data for Form F, however, are only available through the publisher (Center for Study of Higher Education, Berkeley, California). The range of reported reliabilities for the 14 scales using KR_{21} calculations on a normative sample of 7,283 students is from .67 up to .89 with a mean of .81. Test-retest reliability estimates are also reported with considerably smaller numbers of college men and women (67 men and 71 women); these estimates range from .84 to .95, with a mean of .89.

Validity of the OPI is reported in terms of overall correlation between OPI scales ($N=125$, $r=.23$, $p<.01$) and scales on the Allport-Vernon-Lindzey Study of Values. Other validity studies include OPI correlations with the California Psychological Inventory, (N-97 college women, $r=.26$, $p<.01$), and the Minnesota Multiphasic Personality Inventory (N-72 college students, r-.30, $p<.01$). No reliability or

validity measures are available for black college students. A brief description of the scales may be found in the appendix.

Development and Description of the Gaming Questionnaire (Student Attitude Toward Instructional Games)

This questionnaire, developed at the Florida State University Computer-Assisted Instruction Center, was a pilot instrument. The measure attempted to determine the student's attitude toward various aspects of the teaching game. The 70-question form took an average of 15 minutes to administer. The design of the test was to first present a statement about teaching games. The student represents his agreement or disagreement with the statement by circling one of the five levels on the scale. Adair (1970) reports a KR_{20} reliability of .95 (N-58) for this questionnaire. The entire questionnaire may be found in the appendix.

The use of these materials and details of the experimental part of this study are given in Chapter III.

CHAPTER III

DESIGN AND PROCEDURES

Interpretation of Variables

The primary independent variables used in this study are treatment groups (lecture-discussion and gaming). Pretest or entry variables of attitude towards science, confidence in science, general science achievement and mastery of specific science concepts were used as dependent variables to compare the groups to determine whether analysis of covariance would be required to make accurate group comparisons. These same variables were collected again in the posttest to be used in a series of two-factor analysis of variance designs with repeated measures on one factor. These designs were used to test the level of significance of differences in the dependent variables found between the two treatment groups (independent variables).

The remainder of the variables collected in this study may be generally classified as predictor variables. These include background variables, attitude variables, personality inventory scores, questionnaire responses, and total game scores. These measures were collected for the construction of prediction equations using step-wise multiple regression techniques. Ideally these equations would separate individuals into two groups, those that profit from lecture-discussion techniques and those that benefit from the gaming approach.

Setting of the Experiment

The study was conducted at Florida Agricultural and Mechanical University. It is a state supported institution located in Tallahassee, the capital city, where it has been for most of its eighty-two year history.

The institution became a bi-racial institution at the passage of the Civil Rights Act. Its student population of approximately 4,000 is 99% non-white. However, the faculty of 250 is composed of approximately 85% non-whites.

Historical data in the offices of Placement and Alumni Affairs reveal that more than 50% of the teachers in the predominatly Negro schools in Florida received their preparation at this institution.

Population of the Study

The population of subjects participating in the study consisted of 78 teachers enrolled in two graduate level science education courses. They ranged in age from 22 through 58 years (mean of 35 and SD of 11) and consisted of approximately 20% men and 80% women. These returning teachers taught at all levels from kindergarten through junior high school. Approximately half of these students were enrolled in master's degree programs and the remainder were accumulating hours for certification.

The Graduate Academic Advisement Office of Florida A & M University reports a wide variance in achievement among these students. Some have verbal and communicative difficulties that limit their achievement. At the other end of the spectrum there are several students in every class that could achieve more rapidly than many of their classmembers.

The Experimental Design

The test, game, background and general achievement measure, criterion measure, Omnibus Personality Inventory Form Fy, and gaming questionnaire used in the study and described in Chapter II will be designated in the remainder of this paper by the identifying letters as follows:

TEXT (T): The text used by both the experimental and control groups was "Elementary School Science and How to Teach It" by Blough and Schwartz.

GAME (G): The game of "Challenge" was developed to be used as the experimental treatment. Its use with the experimental group will be described in further detail later.

BACKGROUND AND GENERAL ACHIEVEMENT MEASURE (A): This measure was designed to serve three purposes. First, to collect relevant background and attitudinal measures. Second, to measure the student's current achievement in science content appropriate for the elementary school. Finally to measure the student's confidence in this science content. This measure was given to both treatment groups.

CRITERION MEASURE (C): This measure was designed to appraise the student's mastery of the 72 concepts taught by the gaming episodes. This measure was given to both treatment groups.

OMNIBUS PERSONALITY INVENTORY FORM Fy (OPI): The OPI was included in the testing program of both treatment groups to estimate personality variables that might be related to performance on the achievement and criterion measures.

GAMING QUESTIONNAIRE (Q): This measure, called the Student Attitude Toward Instructional Games, was included to determine the student's attitude toward various aspects of the teaching game. This measure was given only to the experimental treatment.

The "Nonequivalent Control Group Design" as described by Cambell and Stanley (1966) was used to investigate the research hypotheses. These authors report that this design is common in educational research where "naturally assembled collectives such as classrooms (1966, p. 47)" are conveniently available and more practical for

use in student assignment than strictly random means. Control is said to be maintained over all extraneous variables related to both internal and external validity with the possible exception of regression, interaction of testing and treatment, interaction of selection and treatment, and reactive arrangements. However, it is felt that the design of this study has provided effective controls over these variables.

The treatment period for this study was eight weeks, the length of the Summer quarter at Florida A & M University. Pre-treatment data were gathered during the first week of the quarter for both groups. Data were gathered also after the eight-week period of instruction had terminated. Pre- and post-treatment measures required two one hour class sessions for completion by both groups. These were administered during the second and third class period and again during the final examination period.

The sequence of data gathering can be seen by examining Figure 2.

	Pre-treatment	Treatment Period	Post-treatment
Experimental Group	General measure (A) Criterion measure (C) Personality Inventory (OPI)	One 8-week Quarter Thirteen teaching games administered, taking 15 hours of class time	General Measure (A) Criterion Measure (C) Gaming Questionnaire (Q)
Control Group	General measure (A) Criterion measure (C) Personality Inventory (OPI)	Fifteen hours of class time used for lecture-discussion	General measure (A) Criterion Measure (C)

Fig. 2.--Sequence of events in the experiment.

Treatment Group Procedure

The students assigned themselves to one of two classes depending on the class section they chose. Both were morning classes on a Monday, Wednesday and Friday schedule. The students were not informed as to the instructors for the two classes or that there would be a difference of treatment between classes. The only selection factor that appeared to be significant was the time of day the class met and how it fit into the student's schedule. The assignment of instructor to classes was also conducted in an arbitrary manner to conform to his other class assignments. The method of selection of students and instructors and the size of the classes (39 and 37) were expected to control the limitations that may be present in this type of experimental design. This assumption was tested by comparing means and variance on pretest measures for the two groups. The results of these comparisons may be found in Chapter IV.

The instructors teaching the two groups decided that one half of the quarter would be devoted to the review of science content. This half of a quarter reduced to 15 hours of classroom instruction. Parallel weekly assignments were planned to insure that both groups considered the same chapter at nearly identical times. Both groups were informed that approximately half of their final grade would be determined by their mastery of the science content covered in the course.

The control group used a traditional lecture-discussion approach. The instructor had taught the course approximately two times a year for the last five years. This investigator visited the control group five times during the lecture-discussion sessions and the

instructor's strategy was to quickly review major concepts of the assigned chapter and then ask leading questions of the class. These questions usually stimulated class discussion that filled the remainder of the class period. The atmosphere of the class appeared to be calm and relaxed during this investigator's visits. A good relationship seemed to be present between members of the class themselves and toward their instructor. The control class thus appeared to represent a good example of the lecture-discussion treatment.

The experimental group used a learning game in place of the traditional lecture-discussion. A warm-up period was scheduled that introduced the procedures and strategy of the game and provided sample gaming episodes. This was judged important to insure that early games were not less instructive due to confusion over gaming procedures. Directions for the game may be found in the appendix.

When the first regular game was administered the class reported they felt at ease with the technique (informal discussions with group members were the basis of this judgment). Thirteen separate gaming sessions were conducted that required an average of one hour each. Groups finishing early used the remaining time to discuss the concepts taught in the game. This investigator's observation of the gaming sessions and his incidental discussions with students suggested that the games were, in general, well received by the class and were a source of motivation for the course. The results of the gaming questionnaire reported in Chapter IV will further evaluate the class acceptance of the game.

The instructor of the experimental group was the investigator of this study. He had taught the course one time before, using the lecture-discussion technique. The instructor was available to answer procedural questions, but did not become involved with discussions of the concepts taught in the games. This was thought to be important in keeping the two treatments as pure as possible.

CHAPTER IV

RESULTS

The results of the analyses performed are presented in this chapter under four headings. First, the two treatment groups are compared using five premeasures (science achievement, criterion score, attitude toward science, total general confidence in science, and total specific confidence in science). *t* tests were computed to measure possible differences between groups on these pre-experimental measures.

Second, experimental results are reported which measure the comparative effectiveness of the experimental and control treatments (gaming and lecture-discussion). This section includes five analyses of variance comparisons.

The third section presents the results of using premeasures of background, attitude, and personality in predicting the five dependent variables of major interest in this study (science achievement, criterion score, attitude toward science, total general confidence in science, and total specific confidence in science). Five sets of stepwise multiple regression analyses are used for this purpose.

Section four is concerned with the experimental group's attitude toward the game and their total game score. Correlations between these variables and the five dependent variables mentioned above were performed. Next, the premeasures used above were included in two stepwise multiple regression analyses to predict the dependent variables of attitude toward the game and total game score.

Comparison of Treatment Groups

To avoid spurious interpretations, a comparison between treatment groups was performed using five premeasures (science achievement, criterion score, attitude toward science, total general confidence in science, and total specific confidence in science). To perform these analyses, and other analyses in this study, two students were randomly deleted from the experimental group in order to make both treatment groups of equal size (N=37 for each group). The results of the analyses discussed above appear in Table 1.

TABLE 1. Mean difference analysis: control vs. experimental on premeasures of achievement in science, criterion score, attitude toward science, general confidence in science, and specific specific confidence in science

Measure	Experimental Group		Control Group		
	Mean	S.E.	Mean	S.E.	t
Achievement	45.97	1.47	46.29	1.54	.21, N.S.
Criterion score	27.15	.84	26.18	.97	.76, N.S.
Attitude	4.00	.13	3.73	.15	1.40, N.S.
General Confidence	9.32	.37	9.95	.43	1.10, N.S.
Specific Confidence	247.93	7.87	259.77	7.41	1.09, N.S.

Note: 72 degrees of freedom were used in all t tests.

The five t tests performed above indicate that for the five dependent variables, considered major dependent variables in this study, the two groups did not differ significantly at the beginning of the

experiment. The use of the analysis of variance design to compare pre and post measures of these dependent variables was thus judged appropriate.

Comparative Evaluation

Comparisons between the experimental gaming group and the control lecture-discussion group were made in five analysis of variance designs (using a repeated measure design): (1) the two groups were compared with the score on four subtests of the achievement test as the dependent variable, (2) a comparison between groups was made using the two subtest scores (life and physical science) on the criterion test as the dependent variable, (3) the two groups were compared with a one item attitude toward science measure as the dependent variable, (4) the two groups were compared using four scores on the general confidence measure (confidence in the life, physical, chemical, and earth sciences) as the dependent variable, 5) the two groups were compared using the four scores on a specific confidence in science measure (confidence on the life, physical, chemical, and earth science subtests) as the dependent measure. The results of these analyses are reported in Table 2 through 6.

Table 2 shows a significant main effect for groups, pretest-posttest administration, and for subtests. The interaction between groups and pretest-posttest administration is also significant. The means of the pretests were compared previously (Table 1) and found to not differ significantly. The posttest means (49.12 for the control and 57.98 for the experimental group) would indicate that the significant F's found are a result of a significant difference in posttest

TABLE 2. Analysis of variance: control vs. experimental on general achievement segmented by four subtests

Source of variance	df	SS	MS	F	Probability
Groups (G)	1	164.43	164.43	5.27	.05
Subjects (J(G)) Error	72	2242.84	31.15		
Pretest-Posttest (P)	1	496.22	496.22	73.06	.01
G X P	1	181.73	181.73	26.72	.01
J X P (G) Error	72	486.80	6.73		
Subtests (S)	6	485.39	80.90	17.21	.01
G X S	6	66.38	11.06	2.34	
J X S (GP)	432	2039.23	4.72		

Means:	Experimental		Control	
	Pretest	Posttest	Pretest	Posttest
General Achievement	45.95	57.98	46.29	49.12
Achievement Life sciences	13.71	15.39	12.46	12.89
Achievement Physical sciences	10.63	14.03	11.18	12.28
Achievement Chemical sciences	12.00	14.33	12.24	12.64
Achievement Earth sciences	9.63	14.23	10.41	11.31

achievement between the groups, with the experimental group being superior. The presubtest scores for the experimental and control groups showed a superior performance on the life and chemical sciences.

The two groups did, however, tend to equalize these differences on the posttest, with the life sciences score still being higher. The sum of the four subtests is equal to the general achievement score.

Table 3 shows a significant main effect for groups and also a significant interaction between groups and pretest-posttest administration. The means of the pretests were compared previously and found

TABLE 3. Analysis of variance: control vs. experimental on criterion measure segmented by two subtests

Source of variance	df	SS	MS	F	Probability
Groups (G)	1	1144.34	1144.34	41.61	.01
Subjects (J(G)) Error	72	1980.78	27.51		
Pretest-posttest (P)	1	1552.99	1552.99	177.68	.01
G X P	1	878.72	878.72	100.54	.01
J X P(G) Error	72	629.30	8.74		
Subtests (S)	2	12.59	6.30	.94	
G X S	2	41.95	20.97	3.11	
J X S (GP) Error	144	970.46	6.74		

Means:	Experimental	Control
Pretest	27.15	26.18
Posttest	43.24	28.45
Pretest Life sciences	13.02	13.51
Posttest Life sciences	21.67	14.72
Pretest Physical sciences	14.13	12.67
Posttest Physical sciences	21.57	13.73

not to differ significantly. The posttest means (28.45 for the control and 43.24 for the experimental group) would indicate that the significant F's found are a result of a significant difference in posttest scores between groups, with the experimental group being superior. No significant differences were detected between subtests.

Table 4 shows a significant main effect for groups and a significant interaction between groups and pretest-posttest administration. The means of the pretests were compared previously and found not to differ significantly. The posttest means (3.54 for the control and 4.46 for the experimental group) would indicate that the significant F's found are a result of a significant difference in posttest measures of attitude toward science, with the experimental group being superior.

TABLE 4. Analysis of variance: control vs. experimental on one item attitude toward science measure

Source of variance	df	SS	MS	F	Probability
Groups (G)	1	13.08	13.08	11.47	.01
Subjects (J(G) Error	72	82.24	1.14		
Pretest-Posttest (P)	1	.68	.68	3.61	
G X P	1	3.89	3.89	20.81	.01
J X P (G) Error	72	13.43	.19		

Means:	Experimental	Control
Pretest	4.00	3.73
Posttest	4.46	3.54

It is interesting to note that the experimental group increased .43 points from pretest to posttest, while the control decreased .19 points over the same time period. The experimental group thus displayed a more positive attitude toward science at the end of the course than at the beginning, while the reverse was true of the control group.

Table 5 shows a significant main effect for pretest-posttest administration and subtests. A significant interaction is also reported between groups and pretest-posttest administration. The means were compared previously (Table 1) and found not to differ significantly. The posttest means (10.94 for the control and 12.55 for the experimental group) would indicate that the significant F's found are a result of superior posttest scores recorded by the experimental group. A t test was performed between the posttest means (experimental and control) and a significant difference was detected. A significant difference between subtests was also detected in this analysis. The life science measure was highest on the pretest for both the experimental and control groups. The chemical science measure was the lowest on the pretests of the two groups. These differences appeared to be reduced on the posttest. t test comparisons revealed that the control's pretest in life and chemical sciences and the experimental group's pretest in the chemical sciences were significantly different from the other sources in the column.

The analysis of variance for specific confidence (Table 6) revealed significant main effects for groups, pretest-posttest administration and subtests. A significant interaction is also present between groups and pretest-posttest administration. The means were

TABLE 5. Analysis of variance: control vs. experimental on total general confidence in science segmented by four subtests

Source of variance	df	SS	MS	F	Probability
Groups (G)	1	2.44	2.44	.74	
Subjects (J (G)) Error	72	236.51	3.29		
Pretest-Posttest (P)	1	37.00	37.00	62.29	.01
G X P	1	12.49	12.49	20.47	.01
J X P (G) Error	72	43.76	.61		
Subtests (S)	6	19.54	3.26	10.16	.01
G X S	6	1.53	.25	.78	
J X S (GP) Error	432	138.43	.32		

Means:	Experimental		Control	
	Pretest	Posttest	Pretest	Posttest
General Confidence Total	9.32	12.55	9.95	10.94
General Confidence Life Sciences	2.56	3.16	2.88	2.94
General Confidence Physical sciences	2.36	3.06	2.52	2.61
General Confidence Chemical sciences	1.97	3.11	2.13	2.61
General Confidence Earth sciences	2.44	3.22	2.52	2.78

TABLE 6. Analysis of variance: control vs. experimental on total specific confidence in science segmented by four subtests of the achievement test

Source of variance	df	SS	MS	F	Probability
Groups (G)	1	5644.57	5644.57	7.60	.01
Subjects (J (G)) Error	72	53444.89	742.29		
Pretest-posttest (P)	1	18306.19	18306.19	41.73	.01
G X P	1	5388.17	5388.17	41.77	.01
J X P (G) Error	72	9296.64	129.12		
Subtests (S)	6	4116.86	686.14	8.16	.01
G X S	6	672.75	112.13	1.35	
J X S (GP)	432	35817.39	82.91		

Means:	Experimental		Control	
	Pretest	Postest	Pretest	Posttest
Specific Confidence Total	247.93	337.23	259.77	280.26
Specific Confidence Life sciences	70.31	83.14	68.88	74.06
Specific Confidence Physical sciences	63.28	81.42	61.06	66.06
Specific Confidence Chemical sciences	62.81	80.67	64.61	70.00
Specific Confidence Earth sciences	61.53	82.00	65.22	70.14

compared (Table 1) previously and were found not to differ significantly. The posttest means (280.26 for the control and 337.23 for the experimental group) would indicate that the significant F's found are a result of a significant difference in posttest measures of total specific confidence in science, with the experimental group performing in a superior manner. t tests indicated that the significant difference found between subtests were a result of differences in the experimental and control group's pretest and posttest specific confidence measures in the life sciences and the control's pretest and posttest measures of the physical sciences.

The Relationship Between Predictor Variables and Five Treatment Effects

This section presents the results of using pretreatment measures of background, attitude, and personality in predicting the control and experimental group's post achievement in science, post criterion score, post attitude toward science measure, post total general confidence in science, and post total specific confidence in science. The treatment groups were divided into high and low performers by their score on the pretest measure of achievement in science. The high group represented the top 50% of the scores and the low the remainder. This procedure was performed to detect differential treatment effects for these two classifications. Table 7 displays the pretest and posttest means for the four classifications (low and high experimental and low and high control) on the seven primary dependent variables considered in this study. Five sets of stepwise multiple regression analyses were used to make these predictions. Each set

TABLE 7. Means and standard deviations: experimental and control groups on seven dependent variables

	Experimental low	Experimental high	Control low	Control high
Pre-achievement	38.94 (5.87)*	52.94 (5.25)	39.06 (6.34)	53.94 (4.71)
Post-achievement	56.72 (5.56)	59.44 (6.58)	41.78 (7.67)	57.70 (5.34)
Pre-attitude	3.94 (.87)	4.11 (.68)	3.50 (.76)	4.11 (.76)
Post-attitude	4.44 (.62)	4.50 (.52)	3.50 (.92)	3.72 (.75)
Pre-criterion	25.50 (5.82)	28.22 (3.83)	23.72 (5.29)	29.17 (5.50)
Post-criterion	43.88 (6.99)	44.33 (3.96)	26.39 (4.51)	31.00 (6.04)
Pre Gen. confid.	8.78 (2.37)	9.72 (2.30)	9.50 (2.18)	10.67 (2.68)
Post Gen. confid.	11.28 (3.23)	13.28 (3.30)	10.39 (2.72)	11.44 (2.79)
Pre Spec. confid.	231.28 (40.40)	281.61 (43.23)	264.28 (37.21)	256.48 (50.10)
Post Spec. confid.	316.17 (42.15)	339.28 (26.44)	292.44 (35.20)	264.17 (36.88)
Attitude toward the Game	280.00 (20.06)	285.00 (32.40)	-----	-----
Total game score	1117.00 (354.00)	1208.00 (433.00)	-----	-----

*Denotes standard deviation

contains four regression analyses. The predictor variables listed below were used in all five sets of analyses:

1. sex
2. college grade point average
3. pre-attitude toward science
4. size of high school
5. high school earth science (yes-no)
6. preferred elementary teaching level
7. number of college science courses
8. attitude toward Computer-Assisted Instruction
9. pre general confidence in science
10. OPI Thinking Introversion (TI)
11. OPI Complexity (CO)
12. OPI Social Extroversion (SE)
13. OPI Social Extroversion (SE)
14. OPI Theoretical Orientation (TO)
15. OPI Masculinity-Femininity (MF)

Table 8 through Table 27 below describe the results of the five sets of stepwise multiple regression analyses performed. In each of these tables the first six predictor variables to be extracted were listed. This procedure was established for two reasons. First, to insure a uniform comparison between tables. Second, because practical application of the regression equations in the instructional setting would dictate that only a few highly predictive variables be used. Of the six variables listed, only those that increased the variance estimate (R^2) by 5% and have significant F's will be considered in the discussion and summary tables (Table 28 and Table 29).

Tables 8 through 11 show the independent variable's coorelation with the dependent variable (post achievement score) as well as the variance estimates (R^2) for each of the variables extracted. For the experimental high and low groups, multiple R^2 (adjusted for small N) after extracting six variables was .46 and .72 respectively. For the high and low control groups, the adjusted multiple R^2 after extracting six variables was .53 and .79 respectively.

TABLE 8. Stepwise multiple regression variance estimates: low experimental post achievement

	Pearson r	R^2
OPI Complexity (CO)	.75	.57*
Pre-attitude toward science	.37	.65*
OPI Social Extroversion (SE)	-.27	.71*
Preferred ele. teaching level	.20	.75
Size of high school	.12	.77
OPI Practical Outlook (PO)	-.22	.80
		(.72)**

*Accounting 5% or more of the variance estimate (R^2)

**R^2 adjusted for sample size

TABLE 9. Stepwise multiple regression variance estimates: high experimental post achievement

	Pearson r	R^2
OPI Thinking Introversion (TI)	.50	.25*
OPI Masculinity-Femininity (MF)	.32	.35*
College grade point average	.27	.43*
OPI Complexity (CO)	.20	.50*
Number of college science courses	-.07	.56
Preferred ele. teaching level	-.07	.62
		(.46)**

*Accounting 5% or more of the variance estimate (R^2)

**R^2 adjusted for sample size

TABLE 10. Stepwise multiple regression variance estimates: low control post achievement

	Pearson r	R^2
OPI Practical Outlook (PO)	-.77	.60*
Pre general confidence	-.69	.69*
High school earth science (yes-no)	.08	.76*
Attitude toward Computer Assisted Instruction	-.10	.80
Size of high school	-.37	.83
OPI Masculinity-Feminity (MF)	.01	.85 (.79)**

*Accounting 5% or more of the variance estimate (R^2)

**R^2 adjusted for sample size

TABLE 11. Stepwise multiple regression variance estimates: high control post achievement

	Pearson r	R^2
OPI Practical Outlook (PO)	-.46	.22*
OPI Theoretical Orientation (TO)	.43	.32*
Number of college science courses	.31	.45*
Pre general confidence in science	.25	.50*
High school earth science (yes-no)	.16	.58
College grade point average	-.13	.67 (.53)**

*Accounting 5% or more of the variance estimate (R^2)

**R^2 adjusted for sample size

Variance estimates for the experimental high and low groups (for general achievement) both included a positive correlation with the Complexity (CO) scale of the OPI. The scale description indicates that high scorers on this scale are generally fond of novel situations and ideas (as might be found in a game). The first predictor extracted among the high and low of the control groups was a negative correlation on the Practical Outlook (PO) scale of the OPI. The scale description states that high scorers usually have nonintellectual interests. The OPI scale of Social Extrovertism (SE) was a predictor, for the low experimental group, that was negatively correlated with post achievement. This might indicate that extroverts in the low experimental group have a tendency to use the game as a source of social satisfaction, without entering into the intellectual aspects of the game.

Tables 12 through 15 show the independent variables' correlation with the dependent variable (post attitude toward science score) as well as the variance estimates (R^2) for each of the variables extracted. For the experimental high and low groups, multiple R^2 (adjusted for small N) after extracting six variables was .41 and .45 respectively. For the high and low control groups, the adjusted multiple R^2 after extracting six variables was .89 and .84 respectively.

The pattern of variables predicting post attitude toward science indicates that pre-attitude is the prime predictor, except for the high control group. Here, the student's preferred elementary teaching level was the prime predictor (a high intercorrelation with the other variables prevented it from being extracted early). Sex is negatively correlated with post attitude in all four analyses. Males appear to have a more positive post attitude toward science than do the females.

TABLE 12. Stepwise multiple regression variance estimates: low experimental post attitude

	Pearson r	R^2
Pre-attitude toward science	.59	.36*
Number of college science courses	-.21	.48*
OPI Theoratical Orientation (TO)	.35	.52
Sex	-.23	.56
Preferred ele. teaching level	-.16	.59
College grade point average	.15	.61 (.45)**

*Accounting 5% or more of the variance estimate (R^2)

**R^2 adjusted for sample size

TABLE 13. Stepwise multiple regression variance estimates: high experimental, post attitude

	Pearson r	R^2
Pre-attitude toward science	.51	.26*
Sex	-.26	.36*
Preferred ele. teaching level	-.22	.44*
Attitude toward Computer Assisted Instruction	-.24	.47
OPI Thinking Introversion (TI)	-.13	.52
OPI Complexity (CO)	.13	.58 (.41)**

*Accounting 5% or more of the variance estimate (R^2)

**R^2 adjusted for sample size

TABLE 14. Stepwise multiple regression variance estimates: low control post attitude

	Pearson r	R^2
Pre-attitude toward science	.85	.72*
Sex	.41	.80*
Preferred ele. teaching level	.12	.84
Attitude toward Computer Assisted Instruction	-.24	.86
OPI Thinking Introversion	-.15	.88
OPI Practical Outlook	-.18	.89 (.84)**

*Accounting 5% or more of the variance estimate (R^2)

**R^2 adjusted for sample size

TABLE 15. Stepwise multiple regression variance estimates: high control post attitude

	Pearson r	R^2
Preferred ele. teaching level	.67	.46*
OPI Theoretical Orientation (TO)	-.31	.78*
Sex	-.37	.84*
OPI Social Extroversion (SE)	-.24	.91*
College grade point average	.15	.91
Number of college science courses	.35	.92 (.89)**

*Accounting 5% or more of the variance estimate (R^2)

**R^2 adjusted for sample size

A negative correlation was also recorded for the number of college science courses predictor in the low experimental group. The individuals that had taken more college science courses had a lower post attitude toward science.

Tables 16 through 19 show the independent variables' correlation with the dependent variable (post criterion score) as well as the variance estimates (R^2) for each of the variables extracted. For the experimental high and low groups, multiple R^2 (adjusted for small N) after extracting six variables was .77 and .69 respectively. For the high and low control groups, the adjusted multiple R^2 after extracting six variables was .72 and .49 respectively. The OPI scale of Social Extroversion (SE) was negatively correlated with post criterion scores on all four analyses. The finding was similiar to the results found in post general achievement. The OPI Complexity (CO) scale was also a prime predictor for both high and low experimental groups. Sex was negatively correlated with post criterion score with both of the experimental groups, but did not appear in either of the control groups.

TABLE 16. Stepwise multiple regression variance estimates: low experimental post criterion

	Pearson r	R^2
Pre-attitude toward science	.52	.27*
Sex	-.47	.38*
OPI Complexity (CO)	.25	.48*
Pre general confidence	.12	.66*
Size of high school	.40	.74*
OPI Theoretical Orientation (TO)	.09	.78 (.69)**

*Accounting 5% or more of the variance estimate (R^2)

**R^2 adjusted for sample size

TABLE 17. Stepwise multiple regression variance estimates: high experimental post criterion

	Pearson r	R^2
OPI Complexity (CO)	.41	.17*
OPI Social Extroversion (SE)	-.30	.32*
High school earth science (yes-no)	-.25	.57*
Sex	-.09	.71*
Size of high school	.11	.79*
Pre-attitude toward science	.07	.84* (.77)**

*Accounting 5% or more of the variance estimate (R^2)

**R^2 adjusted for sample size

TABLE 18. Stepwise multiple regression variance estimates: low control post criterion

	Pearson r	R^2
Pre general confidence	-.57	.32*
High school earth science (yes-no)	-.48	.46*
OPI Theoretical Orientation (TO)	.22	.52*
OPI Social Extroversion (SE)	-.18	.56
College grade point average	.05	.60
OPI Masculinity-Femininity (MF)	.05	.64 (.49)**

*Accounting 5% or more of the variance estimate (R^2)

**R^2 adjusted for sample size

TABLE 19. Stepwise multiple regression variance estimates: high control post criterion

	Pearson r	R^2
Pre-attitude toward science	-.59	.35*
OPI Social Extroversion (SE)	-.53	.50*
College grade point average	.10	.60*
OPI Thinking Introversion (TI)	.25	.68*
Attitude toward Computer Assisted Instruction	-.36	.73*
OPI Practical Outlook	.17	.80 (.72)**

*Accounting 5% or more of the variance estimate (R^2)

**R^2 adjusted for sample size

Tables 20 through 23 show the independent variables' correlation with the dependent variable (post general confidence in science) as well as the variance estimates (R^2) for each of the variables extracted. For the experimental high and low groups, multiple R^2 (adjusted for small N) after extracting six variables was .78 and .73 respectively. For the high and low control groups, the adjusted multiple R^2 after extracting six variables was .89 and .79 respectively. The pre general confidence scale is the prime predictor of post general confidence for all four groups. The number of college science courses is again negatively correlated with the dependent variable for the low experimental group as it was in post attitude. The remainder of the variable are mixed and do not present definite patterns.

TABLE 20. Stepwise multiple regression variance estimates: low experimental general confidence

	Pearson r	R^2
Pre general confidence in science	.57	.33*
Number of college science courses	-.29	.51*
High school earth science (yes-no)	-.25	.59*
OPI Theoretical Orientation (TO)	.27	.66*
OPI Social Extroversion (SE)	-.05	.73*
OPI Practical Outlook (PO)	-.03	.81* (.73)**

*Accounting 5% or more of the variance estimate (R^2)

**R^2 adjusted for sample size

TABLE 21. Stepwise multiple regression variance estimates: high experimental general confidence

	Pearson r	R^2
Pre general attitude toward science	.71	.51*
Size of high school	.43	.60*
OPI Thinking Introversion (TI)	-.10	.76*
Preferred ele. teaching level	.14	.82
OPI Theoretical Orientation (TO)	.23	.84
High school earth science (yes-no)	.02	.87 (.78)**

*Accounting 5% or more of the variance estimate (R^2)

**R^2 adjusted for sample size

TABLE 22. Stepwise multiple regression variance estimates: low control general confidence

	Pearson r	R^2
Pre-general confidence	.72	.52*
Sex	-.42	.61*
OPI Social Extroversion (SE)	-.38	.70*
OPI Practical Outlook (PO)	.42	.75*
OPI Complexity (CO)	.04	.81*
OPI Masculinity-Femininity (MF)	-.07	.85 (.79)**

*Accounting 5% or more of the variance estimate (R^2)

**R^2 adjusted for sample size

TABLE 23. Stepwise multiple regression variance estimates: high control general confidence

	Pearson r	R^2
Pre general confidence	.74	.54*
OPI Practical Outlook (PO)	.21	.68*
High school earth science (yes-no)	-.43	.73*
OPI Masculinity-Femininity (MF)	.21	.79*
Preferred ele. teaching level	.39	.87*
OPI Theoretical Orientation (TO)	.50	.92* (.89)*

*Accounting 5% or more of the variance estimate (R^2)

**R^2 adjusted for sample size

Tables 24 through 27 show the independent variables' correlation with the dependent variable (post specific confidence in science) as well as the variance estimates (R^2) for each of the variables extracted. For the experimental high and low groups, multiple R^2 (adjusted for small N) after extracting six variables was .69 and .53 respectively. For the high and low control groups, the adjusted multiple R^2 after extracting six variables was .49 and .23 respectively. The pre general confidence measure and the size of the high school were the two prime predictors for the low and high experimental groups. The control groups did not present any consistent patterns.

TABLE 24. Stepwise multiple regression variance estimates: low experimental specific confidence

	Pearson r	R^2
Pre general confidence	.56	.31*
Size of high school	-.01	.49*
Sex	.03	.57*
OPI Complexity (CO)	-.05	.64*
Number of college science courses	-.14	.66
OPI Social Extroversion (SE)	.13	.69 (.53)**

*Accounting 5% or more of the variance estimate (R^2)

**R^2 adjusted for sample size

TABLE 25. Stepwise multiple regression variance estimates: high experimental specific confidence

	Pearson r	R^2
Size of high school	.61	.37*
Pre general confidence	.49	.52*
Attitude toward Computer Assisted Instruction	-.40	.61*
Sex	-.37	.68*
OPI Social Extroversion (SE)	.06	.74*
OPI Thinking Introversion (TI)	.12	.78 (.69)**

*Accounting 5% or more of the variance estimate (R^2)

**R^2 adjusted for sample size

TABLE 26. Stepwise multiple regression variance estimates: low control specific confidence

	Pearson r	R^2
OPI Complexity (CO)	.42	.17*
OPI Practical Outlook (PO)	.14	.24*
OPI Social Extroversion (SE)	.10	.30*
Size of high school	.23	.33
College grade point average	.27	.37
OPI Theoretical Orientation (TO)	.23	.45 (.23)*

*Accounting 5% or more of the variance estimate (R^2)

**R^2 adjusted for sample size

TABLE 27. Stepwise multiple regression variance estimates: high control specific confidence

	Pearson r	R^2
OPI Thinking Introversion (TI)	-.43	.18*
Pre general confidence	.37	.32*
Size of high school	-.04	.39*
Pre-attitude toward science	-.05	.50*
Sex	-.16	.56*
Number of college science courses	.31	.64* (.49)**

*Accounting 5% or more of the variance estimate (R^2)

**R^2 adjusted for sample size

Tables 28 and 29 below list predictors that account for 5% or more of the variance estimate of the prediction equations included in this section. These tables separated the predictor variables according to those that were common and unique predictors for the various classifications.

TABLE 28. Predictors for achievement and criterion score which account for 5% or more of the variance estimate

	Experimental	Control
Common Predictors	OPI Complexity (CO) Pre attitude toward science OPI Social Extroversion (SE) Sex Size of High school	OPI Practical Outlook (PO) Total general confid. High school earth science (yes-no) OPI Theoretical Orientation (TO)
Unique Predictors	OPI Thinking Introversion (TI) OPI Masculinity-Femininity (MF) College grade point average OPI Complexity (CO) Pre general confid. in science High school earth science (yes-no)	Number of college science courses pre general attitude toward science OPI School extroversion (SE) College grade point average OPI Thinking Introversion (TI) Attitude toward Computer Assisted Instruction

TABLE 29. Predictors for attitude and confidence which account for 5% or more of the variance estimate

Experimental	Control
OPI Complexity (CO)	OPI Practical Orientation (PO)
Pre general attitude toward science	pre general confidence in science
OPI Social Extroversion (SE)	OPI Theoretical Orientation
Sex	
Size of high school	
OPI Thinking Introversion (TI)	Number of college science courses
OPI Masculinity-Femininity (MF)	Pre total attitude toward science
College grade point average	OPI Social Extrovertism (SE)
OPI Complexity (CO)	College Grade point average
Pre general confidence in science	OPI Thinking Introversion (TI)
High school earth science	Attitude toward Computer Assisted Instruction

The Relationship Between Attitude Toward the Game and Total Game Score and Other Selected Variables

This section is concerned with the experimental group's attitude toward the game and their total game score. The dependent variables used are the sum of a gaming questionnaire measuring attitude toward the game and a total game score computed from the separate game scores. Table 30 displays a correlation matrix for the above two variables and other important dependent variables used in this study.

Table 30 indicates that there is a significant correlation ($p < .05$) between a student's attitude toward the game and his post achievement score. There is further a significant correlation ($p < .01$) between the student's attitude toward the game and his post general

TABLE 30. Correlation matrix: attitude towards the game and game score with other important dependent variables

	Post Achievement	Post criterion	post attitude science	post general confid.	post specific confid.
Attitude toward the game	.33*	.04	.02	.52**	.27
Game total score	.17	.09	.28	.53**	.22

	Mean	S.D.
Attitude toward the game	283.78	27.62
Game Total score	1208.11	394.67

*indicates significant .05 level

**indicates significant .01 level

confidence in science. The total game score also correlates significantly ($p < .01$) with the post general confidence in science.

The fifteen premeasures used in the previous section are used again in the analyses presented in Table 31 through 34. Here they are used in a stepwise multiple regression analysis that uses attitude toward the game and total game score as the dependent variables.

Table 31 shows the prediction of total game score for the low experimental group. The adjusted multiple R^2 after extracting six variables was .40. Table 32 shows the prediction of total game score for the high experimental group. The adjusted multiple R^2 after extracting six variables was .56. The pattern of variables are very mixed for the two groups. The OPI scales of Complexity (CO) and

TABLE 31.--Stepwise multiple regression variance estimate low experimental group's total game score

	Pearson r	R^2
OPI Complexity (CO)	.54	.29*
OPI Practical Outlook (PO)	-.47	.38*
OPI Social Extroversion (SE)	.27	.43*
Pre general confidence	.34	.47
Sex	.22	.54
OPI Thinking Introversion (TI)	.24	.58 (.40)**

*Accounting 5% or more of the variance estimate (R^2)

**R^2 adjusted for sample size

TABLE 32.--Stepwise multiple regression variance estimate high experimental group's total game score

	Pearson r	
OPI Masculinity-Femininity (MF)	.50	.25*
Size of high school	.41	.38*
Preferred elementary teaching level	-.20	.47*
OPI Practical Outlook	.39	.57*
Pre general confidence	.13	.65
OPI Thinking Introversion (TI)	-.10	.69 (.56)**

*Accounting 5% or more of the variance estimate (R^2)

**R^2 adjusted for sample size

Practical Outlook (PO) are the prime predictors and the low experimental group. The OPI scale of Masculinity-Femininity (MF) and the size of the high school are the prime predictors for the high experimental group. Adair (1970) states that prediction of total game score is typically very difficult. Many factors are said to influence the scores that are recorded.

Table 33 shows the prediction of attitude toward the game for the low experimental group. The adjusted multiple R^2 after extracting six variables was .59. Table 34 shows the prediction of total attitude toward the game for the high experimental group. The adjusted multiple R^2 after extracting six variables was .66. The pattern of predictors are very mixed. No predictor that accounts for 5% or more of the variance is found in both tables.

TABLE 33.--Stepwise multiple regression variance estimate low experimental group's attitude toward the game

	Pearson r	R^2
OPI Theoretical Orientation (TO)	.47	.22*
High school earth science (yes-no)	-.37	.36*
Number of college science courses	-.23	.44*
Sex	-.12	.56*
OPI Masculinity-Femininity (MF)	.31	.66*
OPI Complexity (CO)	.34	.71* (.59)**

*Accounting 5% or more of the variance estimate (R^2)

**R^2 adjusted for sample size

TABLE 34.--Stepwise multiple regression variance estimate high experimental group's attitude toward the game

	Pearson r	R^2
Attitude toward Computer Assisted Instruction	-.52	.27*
Pre general confidence	.30	.39*
Preferred elementary teaching level	-.29	.52*
OPI Thinking Introversion (TI)	.44	.65*
OPI Complexity (CO)	-.26	.71*
Pre attitude toward science	.27	.75* (.66)**

*Accounting 5% or more of the variance estimate (R^2)

**R^2 adjusted for sample size

CHAPTER V

DISCUSSION

Analyses of the Effect of the Two Treatments

An analysis of variance design (reported in Table 2) was used to test the following research hypothesis:

> The regular use of a science education game as a teaching strategy with black graduate students results in a measurable improvement in their general science achievement as compared to students taught with lecture-discussion techniques.

A significant main effect for groups, and pretest-posttest administration was detected. The interaction between groups and pretest-posttest administration was also significant. The means of the pretests were compared (Table 1) and found not to differ significantly. The posttest means (49.12 for the control and 57.98 for the experimental group) would indicate that the significant F's found were a result of a significant difference in posttest achievement between groups, with the experimental group being superior. The research hypothesis of a superiority in posttest science achievement for the gaming treatment was therefore confirmed.

A significant difference was also found on subtests. Pretest means for the two treatments showed the life sciences scoring highest, followed by the chemical sciences, physical sciences, and earth sciences. Posttest means for both treatments showed the life sciences highest, but the other three areas were nearly equal. F tests revealed

significant differences between the pre and post subtest scores for all four areas of science in the experimental group. Significant F's were also found between experimental and control post subtest scores in all four areas.

The results on the science achievement test can be interpreted as indicating that the members of the gaming group were more motivated to study their test assignments than were the lecture-discussion group. Students in the gaming group indicated, by informal interview, that they usually made good preparation for class since the game displayed their weaknesses. It is speculated that the students in the lecture-discussion group did not read their assignments as regularly as the experimental group and were forced into last minute reading before the final examination. The gaming strategy was thus thought to promote achievement in science by motivating students to perform their outside reading in a meaningful and regular fashion. These interpretations were based on observation and informal interviews, rather than being based on data.

The following research hypothesis was tested by an analysis of variance design (Table 3):

> The use of a science education game with students will result in a measurable difference in their mastery of specific science concepts (taught in the game) as compared with students taught with lecture-discussion techniques.

A significant main effect for groups and pretest-posttest administration was displayed (Table 3). A significant interaction between groups and pretest-posttest administration is also revealed. Again (Table 1), t tests indicated that pretest means between treatment groups did not differ significantly. Posttest means did, however, differ significantly

(28.45 for the control group and 43.24 for the experimental group). The significant F's found were thus a result of a significant difference in posttest criterion scores between groups, with the experimental group being superior. The research hypothesis of a superiority in posttest criterion score for the gaming treatment was therefore confirmed. A significant difference on subtests was not shown in this table.

The criterion test contained questions covering specific science concepts embedded in the games. Both groups studied these concepts in their reading assignments. The superior performance on the criterion test by the experimental group suggests that the game served to focus the student's attention on these concepts and perhaps show their relevance to science teaching. The superior performance of the gaming group on this posttest suggests that games are capable of teaching as well as motivating the students.

The third research hypothesis tested (Table 4) was:

> The regular use of a science education game as a teaching strategy with students results in a measurable improvement in their attitude toward science, as compared to students taught with lecture-discussion techniques.

A significant main effect for groups and a significant interaction for groups and pretest-posttest administration was found (Table 4). *t* test results (Table 1) reject the hypothesis that there is a difference in pretest means for the two treatments. The control group drops from a mean of 3.73 on the pretest to a mean of 3.54 on the posttest, while the experimental group increases from a mean of 4.00 to 4.46 on the same measures. The significant F's reported in the table are thus a result of the significant increase in posttest attitude toward science

recorded by the gaming treatment. The research hypothesis concerning changes in attitude toward science was thus confirmed.

The improvement in attitude toward science on the post measure for the gaming group suggests that the gaming strategy was efficient in reducing their negative conception of science. The lecture-discussion group actually lowered their attitude toward science on the post measure. This strategy was probably similar to the one the students experienced in high school and at college which established their original attitude toward science. The superior achievement exhibited by the gaming group may further have improved their attitude toward science.

Two analysis of variance designs (Tables 5 and 6) were used to test the following research hypothesis:

> The use of a science education game with students will result in a measurable difference in their confidence in mastery of science concepts as compared with students taught by lecture-discussion.

A significant main effect for pretest-posttest administration of total general confidence was detected. A significant interaction is also shown for groups and pretest-posttest administration. Again, a t test indicates no significant differences between pretest means for the two groups. These significant F's are a result of superior total general confidence displayed by the gaming group, since their posttest measures are substantially higher (10.94 for the control group and 12.55 for the experimental group).

An analysis of variance design for total specific confidence in science was next performed (Table 6). This table displays a significant main effect for groups and pretest-posttest administration.

A significant interaction is also found between groups and pretest-posttest administration. Again, a t test indicates no significant difference between pretest means for the groups. The significant F's are again attributed to higher total specific confidence displayed on the posttest by the gaming group since the posttest means were 280.26 for the control group and 347.93 for the experimental group. A significant main effect for subtests was also discovered. t tests indicated that the significant differences found between subtests were a result of differences in the experimental and control groups pretest and posttest specific confidence measure in the life sciences and the control's pretest and posttest measures in the physical sciences.

These results support the research hypothesis regarding differences in confidence in science between the treatment groups. Both measures (total general and specific confidence) appeared to be sensitive in recording differences in this variable between groups.

The superior confidence displayed by the gaming group on the post measure may be a result of many factors. One factor may be the gaming group's superior achievement in science; that is, confidence should be a direct function of the level of their mastery. Second, the gaming strategy may have increased student confidence by allowing them the opportunity of verbalizing their knowledge of science in front of the gaming group.

The Prediction of Treatment Effects

Means and standard deviations for the seven dependent variables used in stepwise multiple regression were listed (Table 7). The groups were divided into high and low components according to their

performance on the pretest of achievement in science. This dichotomy was formed to determine whether similar factors predicted the dependent measures (achievement, attitude and confidence) for the high and low groups. The high group contained the top half of the distribution and the low group the remainder. The trend throughout this table is for similar pretest values for the experimental and control groups. As reported in the previous section, the experimental gaming group was uniformly superior on the posttest measures.

It is important to note that the experimental low group went from 38.94 on the pretest of science achievement to 56.72 on the posttest, while the experimental high group changed from 52.94 to 59.44 on the two measures. The high and low control groups each gained about 3 points. This would suggest that the gaming technique was more effective in promoting achievement for the low experimental group. The results displayed on the table suggest that different factors may be dictating success for the high and low groups of the two treatments. These high and low classifications were thus used in testing the following research hypothesis:

> Background and personality variables will be differentially useful in predicting success in the two treatments (games and lecture-discussion).

Five sets of stepwise multiple regression analyses were used to predict the five dependent variables of primary interest in this study. Each set contained an analysis for the high and low experimental and control groups. The above research hypothesis may be simplified by saying that it hypothesizes that a different array of the predictors will be useful in prediction of differing groups. This would tend to

indicate that the predictor variables were sensitive enough to detect different factors contributing to the dependent variable measure for the four groups under investigation (high and low experimental and control groups).

This research hypothesis was investigated by comparing the proportion of common and unique predictors in two sets (Tables 28 and 29). The first set was all variables (accounting for 5% or more of the variance) used in the prediction of general achievement in science and criterion score. These were predictors of cognitive success. The second set included all variables (again accounting for 5% or more of the variance) used in the prediction of confidence and attitude toward science. These were predictors of affective success. The first set (Table 28) contained 10 common and 12 unique predictors. The second set (Table 29) contained 8 common and 12 unique predictors. This pattern would suggest that the research hypothesis that background and personality variables will be differentially useful in predicting success in the two treatments was confirmed.

Variance Estimates of the Five Primary Dependent Measures

Twenty tables (Table 8 through Table 27) present the variance estimates (R^2) for the 5 primary dependent variables. Each dependent variable has 4 tables, 1 for each level (high and low) of the experimental and control groups. Baggaley (1964) presents a table which indicates that for the degrees of freedom and number of variables included (for all 20 analyses) a variance estimate (R^2) of .66 is required for it to be significant at the .05 level of significance. This .66 must be the variance estimate for a R^2 corrected for sample size.

The variance estimates for the dependent variable of general achievement in science was first presented (Tables 8 through 11). The low experimental and control group's variance estimates are both significant (.72 and .79 respectively). This finding would suggest that the predictor variables did not measure enough of the relevent factors that determine achievement in science for the high experimental group.

This group did not have the degree of improvement in posttest score that was displayed by the low experimental group. The restricted range may have reduced the power of the variance estimates.

Variance estimates for attitude toward science appeared next (Tables 12 through 15). Both the high and low components of the experimental treatment fell below the significant level (.45 for the high and .41 for the low). Both variance estimates are significant for the control group (.84 for the low and .87 for the high). This finding would suggest that the factors affecting attitude toward science are more complex for the experimental treatment and thus more difficult to predict.

The variance estimates for the criterion measure followed (Tables 16 through 19). Both the high and low experimental group's variance estimates are significant (.77 and .69 respectively). The low control group's variance estimate did not reach the significant level (R^2 = .49). The high control group's variance estimate did reach the significant level (R^2 = .72). The factors important in predicting the low control groups performance on the post criterion measure were not adequately sampled in the 15 predictors selected for the analysis.

Variance estimates for total general confidence in science were the next performed (Tables 20 through 23). Here all four groups reached

the significant level for the variance estimate (R^2 = .73 for the experimental low, .78 for the experimental high, .79 for the control low, and .89 for the control high). The high variance estimates are mostly due to the high correlation between pre and post attitude toward science (pre attitude being one of the predictors).

The variance estimates for total specific confidence in science were the last presented (Table 24 through 27). Here only the variance estimate for the experimental high group is significant (R^2 = .69 for the experimental high, .53 for the experimental low, .23 for the control low, and .49 for the control high). This was the weakest area of prediction for the 15 variables. It is possible the students may fixate on a certain level of the specific confidence scale and thus not record a true measure of their specific confidence. This would serve to make prediction of this measure more difficult.

In all, 20 variance estimates were computed with 12 reaching the significant level (60%). Total general confidence in science appeared to be the dependent variable best estimated by the 15 predictor variables. General science achievement was predicted significantly for the experimental and control low groups, but the high experimental and control group's variance estimates were not significant. Attitude toward science was predicted significantly for both control groups, but fell short for the experimental groups. Total specific confidence was the most difficult dependent variable to predict. Only the experimental high variance estimate was significant for this group.

Most of the variance estimates (60%) were of a high enough level to be practical for prediction where a choice of learning strategies are available. Students entering the science education course used for

this study could respond to the measures required for variance estimates in less than one hour and a half. On the basis of the variance estimates computed, the student might be directed to either the lecture-discussion or gaming treatments.

If the stepwise multiple regression equations are used for student assignments, a search for more sensitive predictor variables should be initiated. The instructor must also decide which of the dependent variables he wishes to maximize for the student (achievement, attitude, or confidence). If differential utility weights are placed on these three learning outcomes, a prediction equation might be constructed which reflects a combined prediction. For this step to be practical many instructional strategies should be available. With the advent of the computer, regression equations are becoming more practical for student assignment.

Many interesting patterns of predictor variables are observed in these variance estimates. Sex was the most frequent variable extracted, appearing 10 times in the 20 tables. Attitude toward computor assisted instruction and the OPI scale of Masculinity-Femininity (MF) were the least frequent predictor variables appearing in the tables (each appearing 4 times). In general all 15 variables appeared frequently in the tables. The mean for all predictor variables was eight appearances in the table (with a standard deviation of 1.55). This data suggests that all 15 variables were useful in several of the variance estimates.

The OPI scale of Social Extrovertism (SE) appeared 9 times in the 20 tables. Six of the 9 times it appeared it was negatively

correlated with the dependent variable. The 3 times it correlated positively were in the variance estimates of total specific confidence. It would appear that social introverts (low scores on this scale) perform better in general in both treatment groups. The social extroverts may be more entertained than instructed by a game.

The OPI scale of Complexity (CO) appeared seven times in the tables. Six of the seven times it correlated positively with the dependent variable (again it correlated negatively in one of the total specific confidence tables). The scale description of Complexity states that high scorers on this scale generally are fond of novel situations and ideas. It is interesting to note that the gaming group had five positive correlations in this area to only two for the control group.

The size of the student's high school appeared nine times in the tables as a predictor variable. In seven of its appearances it correlated positively with the dependent variable and two times it correlated negatively. It would appear that students from large high schools usually score higher on the dependent variables considered in this study.

The predictor variable of preferred elementary teaching level appeared seven times in the tables. Five times teachers preferring upper elementary grades performed in a superior manner on the dependent variable. Teachers preferring lower elementary grades were only superior in two of the tables. In general it may be advanced that teachers preferring the upper elementary level are better performers on the dependent variables included in this study than are teachers who prefer the lower level.

The OPI scale of Practical Outlook (PO) appears eight times in the tables. Five times it is negatively correlated with the dependent variable. The scale description of this predictor describes high scorers on this scale as generally having non-intellectual interests. These results appear to be generally consistent with what would be expected.

Sex appears as a predictor variable 10 times in the tables. Eight times it is positively correlated with the dependent variable. This indicates that women in general score higher on the dependent measures used in this study. This is a surprising finding since males are thought of as surpassing women in their interest and achievement in science.

The OPI scale of Theoretical Orientation (TO) appears nine times in the tables. In eight cases it is positively correlated with the dependent variable. The scale description states that high scorers on this scale are interested in science. The results of this study would tend to support this statement.

The student's attitude toward computer-assisted instruction appears five times in the tables and was negatively correlated with the dependent variable in all five cases. This data indicates that persons scoring high on the dependent variables are more resistent to change brought about by computer-assisted instruction than are the low scores. The high scoring students may be more confident in their teaching ability and not feel that they require aids.

The OPI scale of Masculinity-Femininity (MF) appears four times in the tables. Each time it appears it is positively correlated with

the dependent variable. The scale description for Masculininity-Femininity says that high scorers on this scale are generally interested in scientific matters. This finding in the study is thus consistent with this description.

The other six predictor variables had more mixed results and trends are more difficult to isolate. In general, most of the 15 predictor variables correlated in the direction that would be expected.

Related Questions

A correlation matrix was included to answer the following related research question (Table 30):

> Is there any measurable relationship between attitudes toward the learning game and total game score and the five variables of primary interest in the study (general science achievement score, criterion score, attitude toward science, general confidence, and specific confidence)?

The table reveals that a student's attitude toward the game is significantly positively correlated with his posttest achievement score ($r = .33$) and also with his posttest total general confidence measure ($r = .52$). There was, however, no significant correlation for posttest criterion score, posttest attitude toward science, or total specific confidence in science. Students responding in a positive manner to the gaming questionnaire thus did significantly better on their general science achievement posttest and also indicated a superior total general confidence in science.

This table (Table 30) further reveals that only general confidence is significantly correlated with the total game score ($r = .53$). Achievement and attitude measures show only low to moderate relationships.

Variance estimates were computed for the experimental high and low group's attitude toward the game. The low group had a variance estimate (extracting six variables) of .59, while the high group had .66. The pattern of variables was again mixed. No predictor, that accounted for 5% or more of the variance, is found in both tables. The .66 variance estimate for the high group is significant at the .05 level. Attitude toward the game is thus easier to predict for the high group than the low.

Variance estimates were also computed for the experimental high and low group's total game score. The low group had a variance estimate (extracting six variables) of .40, while the high group had .56. The pattern of variables were very mixed for the two groups. The OPI scales of complexity (CO) and Practical Outlook (PO) were the prime predictors for the low experimental group. The OPI scale of masculinity-femininity (MF) and the size of the high school were prime predictors for the high experimental. Total game score appeared to be a difficult dependent variable to predict. The total game score does not appear to reflect the students' achievement or his attitude toward science. This finding is similar to one reported by Adair (1970). Here scores on a sociology game were poorly correlated with achievement and were difficult to predict.

In conclusion, Chapter V has discussed the results reported in Chapter IV within the framework of the research hypotheses and related questions outlined in Chapter I. The results of analysis of variance comparisons indicated significantly superior posttest results in achievement in science, attitude toward science, confidence in science, and the learning of specific concepts taught in the game for

the experimental gaming group, as compared to the lecture-discussion control group. High and low groups were identified for both the experimental and control treatments on the basis of their pretest measures of achievement in science. Stepwise multiple regression analyses were performed for these four classifications and illustrated that individual personality and background characteristics could differentially predict the post measures. The student attitude toward the game (as measured by a gaming questionnaire) correlated positively with the post achievement and confidence in science measures. The total game score also correlated positively with the post confidence in science measure.

An important finding of this study was that low achievers in science benefitted most from the gaming strategy. Their achievement posttest scores nearly matched those of the high achievement group. The learning game used in this study thus acted to reduce the difference in achievement detected on the pretest, while raising the achievement mean score for the entire group.

Results of this study indicate that a learning game of this type may teach conceptual material, as well as serve as a source of motivation. This finding would suggest that learning games have a more comprehensive role in an instructional system.

The results of this study thus suggest that a learning game of this type may be an effective agent in providing a learning environment that fosters growth in both the cognitive and affective domains.

APPENDICES

APPENDIX A

DIRECTIONS FOR THE GAME

DIRECTIONS FOR "CHALLENGE"

A SCIENCE EDUCATION GAME

Introduction

The game of "Challenge" is designed to allow the player the opportunity of relating his knowledge of science to the elementary classroom situation. A classroom experience is presented in each of the game's episodes. These are followed by a student question that is central to the concept under consideration. The player must assume the role of the teacher and answer the inquiry in a scientifically acceptable manner.

Specific directions

1. The materials required for the play of the game must first be distributed (3-6 players may play the game, with 5 ideal).

each player receives
a. challenge-accept card
b. three cards bearing 5, 15, and 25
other materials
a. score sheet and episode cards
b. start cards

2. Each player draws one of the start cards that have been placed blank side up on the table. The person drawing the card with the highest number is the first judge.

3. The judge for this episode first fills in the players names on the score card. He then opens the first episode card and reads the classroom experience.

4. After the classroom experience has been read, each player must decide how many points he or she wishes to wager on the episode. This decision is made by placing the appropriately numbered card number down in front of him. The judge does not wager in an episode.

5. The judge next reads the student question. The person to the right of the judge is given the first opportunity to give an appropriate reply to the question. He has the option of passing to the person on his right. If he passes he has 5 points subtracted from his score. The turn continues to pass to the right until a player decides to answer the question. If none of the players chose to answer the question, the judge receives 25 points added to his score. This is the only way the judge can accumulate points during an episode.

6. If an answer is given each player (except the judge and person answering) must decide whether the answer is appropriate for the question. The relevance and accuracy of the answer should be weighed. When the decision is made the player places the challenge

or accept face of his card up to indicate his acceptance or rejection of the answer.

7. The judge next reads the answer appearing on the episode card and decides whether the answer given by the player is close enough to be judged correct. An answer should be judged correct if it generally conforms to the answer on the episode card and does not introduce incorrect information. The decision of the judge is final.

8. The player answering the question first turns over the card that represents the number of points he has chosen to wager. If he was correct in his answer he receives two times that number of points added to his score. If he was incorrect and challenged by any player he loses twice the number of points wagered. If he was incorrect in his answer, but not challenged by another player, he receives the number of points added to his score that he wagered. Each of the other players turn up the card representing the number of points wagered. If they accept a correct answer or challenge an incorrect answer they add these number of points to their score. If they challenge a correct answer or accept a wrong answer, the number of points wagered is subtracted from their score.

9. The judge is responsible for recording all points won or lost during the episode. When all points have been recorded the person to the right of the judge becomes the new judge for the next episode. The game continues in a like manner for 6 episodes. The player with the highest number of points at the completion of the game is declared the winner.

Classroom experience

The class is working on a unit on man's progress to the moon. One of the students brought a magazine article which discusses the problems that astronauts will face on the moon. One of the major problems was weighing only 1/6 as much as they do on the earth. A 180 pound astronaut would weigh only 30 pounds on the moon.

Question

The question was raised why a person's weight should vary on the moon and if this might have something to do with the moon lacking an atmosphere.

Answer

A person's weight is a result of his attraction for the body he is near (usually the earth). The larger and more dense the body, the more attraction. There is also more attraction the nearer a person is to the body. This attraction is called gravitation. The moon is much smaller than the earth and thus has only 1/6 the attractive power (or gravity). If the moon ever had an atmosphere it probably was lost due to the moon's weak pull of gravity. The atmosphere probably floated into space.

Concept

Gravitation is a function of a body's density and distance from another object.

EARTH SCIENCE 7-3

Classroom experience

Your class is working on a unit on the eskimos. One student tells the class that he has read that near the north pole they have very long days in one season and long nights in another. Another member of the class says that he has read that we have seasons because the earth's axis is inclined about 23.5°. The class confirms this fact by looking at the globe. He goes on to say different parts of the earth gets different numbers of hours of sunlight each day, depending on the season. The more sunlight that a part of the earth gets, the warmer will be that season. The time when we have the most sunlight is summer.

Question

The question is asked why the snow does not melt in the north pole when they have the long days.

Answer

During this time the sunlight hits the north pole at a large angle. The sunlight is spread over a very large area and thus does not heat the land the way it would if it were direct sunlight (like falls on the equator).

Concept

The cause of the changing seasons.

EARTH SCIENCE 7-4

Classroom experience

One of the members of your class is very interested in astronomy. He was selected to give a report on the subject to the class. In his report he pointed out to the class that we see stars only at night because the light from the sun hides them during the day. He went on to say that the stars appear to rise in the east and set in the west each night. This is due to the revolution of the earth, not because the stars move. The ancient people named many clusters of stars and called these constellations. The constellations visible at night change during the seasons.

Question

The question was asked why the big dipper and the north star can be seen the entire year, while the majority of constellations change from season to season.

Answer

The stars near the north and south poles are near the axis of rotation of the earth. As the earth turns on its axis these stars thus do not change their position very much. A star directly at the north or south pole would not appear to move at all.

Concept

Why the stars at the north and south pole are seen all year.

EARTH SCIENCE 7-5

Classroom experience

A member of the class informed the class that a total eclipse of the sun is due during the week in their area. He goes on to say that during the eclipse the sun will disappear for a few minutes. Another member of the class said that they had an eclipse of the sun a few years ago, but the sun was not completely hidden. Another class member said that he had also heard of an eclipse of the moon.

Question

The question was raised as to what causes the total and partial eclipses of the sun and what was an eclipse of the moon.

Answer

An eclipse of the sun occurs when the moon is in just the right orbit to block the light from the sun from reaching the earth. If the orbit is a little high or a little low a partial blocking occurs and we call this a partial eclipse of the sun. When an eclipse of the sun occurs it only covers a small band on the earth. These eclipses are rare because the moon's orbit around the earth makes an angle with the earth's orbit around the sun, so the moon usually passes too low or too high to cause an eclipse. A lunar eclipse is caused by the earth casting a shadow on the moon.

Concept

The causes of an eclipse of the sun and moon.

APPENDIX C

BACKGROUND AND GENERAL ACHIEVEMENT MEASURE

BACKGROUND AND GENERAL ACHIEVEMENT MEASURE

BIOGRAPHICAL DATA

Please answer the following questions as accurately as possible. Record your responses on the special answer sheet provided. Please do not write on the booklet.

1. Sex a. male b. female

2. Class a. freshmen b. sophomore c. junior
   d. senior e. graduate

3. Overall High School Grade Point Average (choose nearest value)
   a. D or below b. C- to C c. C to C+
   d. B to B+ e. A- to A

4. Science High School Grade Point Average
   a. D or below b. C- to C c. C to C+
   d. B to B+ e. A- to A

5. Mathematics High School Grade Point Average
   a. D or below b. C- to C c. C to C+
   d. B to B+ e. A- to A

6. College Mathematics Grade Point Average
   a. D or below b. C- to C c. C to C+
   d. B to B+ e. A- to A

7. College Mathematics Grade Point Average
   a. D or below b. C- to C c. C to C+
   d. B to B+

8. College Science Grade Point Average
   a. D or below b. C- to C c. C to C+
   d. B to B+ e. A- to A

9. I am Presently taking
   a. my first undergraduate science methods course
   b. my second undergraduate science methods course
   c. a graduate science methods course
   d. none of the above

10. Which of the following best describes your attitude towards Science?
   a. I dislike the subject very much
   b. I dislike the subject most of the time

c. I am neutral towards the subject
d. I enjoy the subject most of the time
e. I enjoy the subject very much

11. Which of the following best describes the enrollment of your High School?
a. 0-100 students b. 100-300 students
c. 300-500 students d. 500-1000 students
e. over 1000 students

12. Would you take an elective science content course if you had room on your schedule?
a. no b. yes

13. Did you take high school chemistry?
a. no1 b. yes

14. Did you take high school physics?
a. no b. yes

15. Did you take high school earth science?
a. no b. yes

16. Did you take high school biology?
a. no b. yes

17. Did you take college chemistry?
a. no b. yes

18. Did you take college physics?
a. no b. yes

19. Did you take college earth science?
a. no b. yes

20. Did you take college biology?
a. no b. yes

21. Do you think elementary science should be taught by a special science teacher rather than by a general classroom teacher?
a. no b. yes

22. I attended high school in
a. Southern Florida b. Northern Florida
c. another part of the south d. the northeast
e. the midwest or far west

23. I would prefer teaching
a. K-2 grade b. 2-4 grade
c. 5-6 grade

24. I feel that science for elementary school children
    a. is a waste of time
    b. is not as important as the other basic subjects
    c. is about of equal importance with the other basic subjects
    d. is more important than the other basic subjects

25. I have taken the following number of college mathematics courses
    a. none
    b. one
    c. two
    d. three
    e. four or more

26. I have taken the following number of college science courses
    a. none
    b. one
    c. two
    d. three
    e. four or more

27. Which of the following describes your feeling towards science laboratory?
    a. I disliked them very much
    b. I disliked them most of the time
    c. I can take them or leave them
    d. I liked them most of the time
    e. I liked them very much

28. If you could take only one science course in college, which of the following would you choose?
    a. physics
    b. chemistry
    c. earth science
    d. biology
    e. public health

29. Which of the following best describes your high school science teachers?
    a. much poorer instructors than my other teachers
    b. a little poorer instructors than my other teachers
    c. about average instructors
    d. a little better than average
    e. much better than most of my other teachers

30. Do you think science is more appropriate for men to teach than women?
    a. no
    b. yes

31. Which of the following techniques do you think is best for teaching science to elementary school children?
    a. carefully explaining the concepts and principles of science
    b. demonstrating the concepts and principles of science using science equipment
    c. letting the children learn the concepts and principles of science for themselves by discovery methods

32. You are an elementary school teacher and your principal has just asked your permission to use a computer to teach science in your classroom. Which of the following would be closest to your responne?
    a. no, I think a computer is an inhuman way of teaching children
    b. no, I think I can do a better job than a computer
    c. maybe, I would have to see what it is like first
    d. yes, I will give it a try
    e. yes, I think it is a very good idea

Skip answer 33 to 39 (on answer sheet)

40. Which of the following statements best describes your knowledge of the general science content that is appropriate for elementary school?
    a. I am very poorly prepared
    b. I know a little about some of the areas of science
    c. I know something about most of the areas of science
    d. I have a pretty good knowledge of most of the areas of science
    e. I feel very well prepared

AREA I The Life Sciences
(includes: animals, plants, reproduction, human body, living things and their habitats, and other related subjects

41. Which of the following statements best describes your knowledge of the areas of the life sciences that are appropriate for elementary school
    a. I am very poorly prepared
    b. I know a little about some of the areas of the life sciences
    c. I know something about most of the areas of the life sciences
    d. I have a pretty good knowledge of most of the area of the life sciences
    e. I feel very well prepared

PLEASE ANSWER ALL THE QUESTIONS BELOW TO THE BEST OF YOUR ABILITY. THE PROBLEMS RANGE IN DIFFICULTY FROM EASY TO HARD. YOU ARE NOT EXPECTED TO ANSWER ALL THE PROBLEMS CORRECTLY. AFTER EACH QUESTION YOU WILL BE ASKED TO RATE YOUR CONFIDENCE IN YOUR ANSWER. YOU ARE PROVIDED A SEPARATE SHEET THAT DESCRIBES THE RATING SCHEME THAT YOU WILL USE THROUGHOUT THE BOOKLET. PLEASE MAKE SURE THAT YOU PLACE YOUR RESPONSES IN THE CORRECT PLACE ON YOUR ANSWER SHEET. IF YOU WISH TO CHANGE YOUR ANSWER ERASE YOUR PREVIOUS ANSWER COMPLETELY.

43. One difference between plants and animals is that only plants contain
    a. carbon
    b. oxygen
    c. cellulos
    d. living matter

44. Your confidence measure for problem 43 (see separate sheet)

45. All fungus plants
    a. are gray or brown in color
    b. are poisonous
    c. are unable to manufacture food
    d. grow on trees

46. Your confidence measure for problem 45

47. Molds and mushrooms grow best in an environment that is
    a. warm and dry
    b. sunny and moist
    c. dark and moist
    d. cold and moist

48. Your confidence measure for problem 47

49. The region in which an organism normally makes its hom is called its
    a. adaptation
    b. habitat
    c. abode
    d. burrow

50. Your confidence measure for problem 49

51. The tiny units of structure and function in the human body are the .
    a. tissues
    b. organs
    c. cells
    d. bones

52. Your confidence measure for problem 51

53. The kidneys, skin, and lungs of the body are similar because they each
    a. aid in breathing
    b. aid in circulation of the blood
    c. aid in digestion
    d. give off body wastes

54. Your confidence measure for problem 53

55. Starches and sugars are
    a. carbohydrates
    b. fats
    c. proteins
    d. minerals

56. Your confidence measure for problem 55

57. All body functions of an individual are coordinated by the
    a. brain
    b. nervous system
    c. heart
    d. circulatory system

58. Your confidence measure for problem 57

59. In a balanced aquarium, plants supply the fish with food and
    a. water
    b. carbon dioxide
    c. oxygen
    d. shelter

60. Your confidence measure for problem 59

61. The type of reproduction which two parents are required is known as
    a. binary fission
    b. asexual reproduction
    c. budding
    d. sexual reproduction

62. Your confidence measure for problem 61

63. Which of the following statements best describes your current estimate of your knowledge of the areas of the life sciences that are appropriate for elementary school
    a. I am very poorly prepared
    b. I know a little about some of the areas of the life sciences
    c. I know something about most of the areas of the life sciences
    d. I have a pretty good knowledge of most of the areas of the life sciences
    e. I feel very well prepared

64. An animal with eight legs is the
    a. ant
    b. house fly
    c. mosquite
    d. spider

65. Your confidence measure for problem 64

66. Feathers are most useful to birds because they
    a. are good heat insulators
    b. lessen the weight of the bird
    c. protect the bird from gun shots and large mammals
    d. have bright colors

67. Your confidence measure for problem 66

68. The smallest living thing which can cause disease in the human is a
    a. protozoan
    b. virus
    c. flea
    d. enzymes

71. Your confidence measure for problem 70

72. Insulin is a substance used to treat people having the disease known as
    a. cancer
    b. diabetes
    c. polio
    d. malaria

73. Your confidence measure for problem 72

74. The stage in its life-history when an insect appears worm-like is
    a. adult
    b. egg
    c. larva
    d. pupa

75. Your confidence measure for problem 74

76. In the human eye, the image is formed on the
    a. pupil
    b. lens
    c. retina
    d. iris

77. Your confidence measure for problem 76

78. The number of calories in a food represents
    a. the vitamin content in the food
    b. the ease with which the food can be digested
    c. the amount of energy that can be obtained from the food
    d. the mineral content of the food

79. Your confidence measure for problem 78

80. The balance of nature among organisms is
    a. permanent
    b. always changing
    c. never disturbed
    d. unaffected by food supply

81. Your confidence measure for problem 80

82. Pollen grains are produced by the
    a. sepals
    b. ovary
    c. pistils
    d. stamens

83. Your confidence measure for problem 82

84. Which of the following statements best describes your current estimate of your knowledge of the areas of the life sciences that are appropriate for elementary school
    a. I am very poorly prepared
    b. I know a little about some of the areas of the life sciences
    c. I know something about most of the areas of the life sciences
    d. I have a pretty good knowledge of most of the areas of the life sciences
    e. I feel very well prepared

AREA II The Physical Sciences
(includes: magnetism and electricity, gravity, friction, light and sound, simple machines, and other related subjects)

85. Which of the following statements best describes your knowledge of the areas of the physical sciences that are appropriate for elementary school
    a. I am very poorly prepared
    b. I know a little about some of the areas of the physical sciences
    c. I know something about most of the areas of the physical sciences
    d. I have a pretty good knowledge of most of the areas of the physical sciences
    e. I feel very well prepared

86. If the S-pole of a bar magnet is brought near the N-pole of another bar magnet, the magnets will
    a. repel each other
    b. lose their magnetism
    c. attract each other
    d. produce an electric spark

87. Your confidence measure for problem 86

88. Of the following, the one that transforms electrical energy into mechanical energy is
    a. a magnetic compass
    b. an electric motor
    c. a dipping needle
    d. a lodestone

89. Your confidence measure for problem 88

90. Of the following, the best conductor of electricity is
    a. iron
    b. copper
    c. tin
    d. zinc

91. Your confidence measure for problem 90

92. An electric lamp produces light because
    a. electricity is bright and yellow
    b. the bulb is filled with argon
    c. the interior of the bulb is a partial vacuum
    d. the wire in the bulb is heated

93. Your confidence measure for problem 92

94. The attraction of the earth for all objects is called
    a. density
    b. pressure
    c. gravity
    d. barometer reading

95. Your confidence measure for problem 94

96. Of the following, a machine does not
    a. multiply force
    b. increase speed
    c. change the direction of a force
    d. increase work

97. Your confidence measure for problem 96

98. The movement of one object over another is slowed down by
    a. gravity
    b. pressure
    c. friction
    d. heat

99. Your confidence measure for problem 98

100. The principle that every action has an equal but opposite reaction was first stated by
a. Einstein
b. Newton
c. Ford
d. Edison

101. Your confidence measure for problem 100

102. The purpose of the lens in a camera is to
a. focus an image on the film
b. cut out the bright rays of the sunlight
c. keep dust away from the film
d. regulate the amount of light entering the camera

103. Your confidence measure for problem 102

104. The warmest air in a room is
a. directly below the radiator
b. in the center of the room
c. near the ceiling
d. near the floor

105. Your confidence measure for problem 104

106. Which of the following statements best describes your current estimate of your knowledge of the areas of the physical sciences that are appropriate for elementary school
a. I am very poorly prepared
b. I know a little about some of the areas of the physical sciences
c. I know something about most of the areas of the physical sciences
d. I have a pretty good knowledge of most of the areas of the physical sciences
e. I feel very well prepared

107. A jet plane is sometimes called supersonic because it is able to travel at a speed greater than that of
a. light
b. a conventional propeller airplane
c. radio waves
d. sound

108. Your confidence measure for problem 107

109. An electric current consists of a flow of electrical particles called
a. neutrons
b. protons
c. electrons
d. neutrinos

110. Your confidence measure for problem 109

111. The push requried to overcome the resistance of gravity is known as
   a. effort force
   b. pressure
   c. weight
   d. inertia

112. Your confidence measure for problem 111

113. At any given depth, the pressure exerted by water is
   a. greater downward than upward
   b. greater sideways than downward
   c. greater upward than downward
   d. the same in all directions

114. Your confidence measure for problem 113

115. A rocket can travel in outer space because it
   a. uses oxygen of the atmosphere
   b. is weightless in space
   c. carries its own oxygen supply
   d. does not require oxygen

116. Your confidence measure problem 115

117. The bending of light rays as they pass from air into water is called
   a. reflection
   b. dispersion
   c. refraction
   d. energy conservation

118. Your confidence measure problem 117

119. In the summer, telegraph wires are strung loosely to allow for
   a. expansion when cooled
   b. contraction when heated
   c. expansion when cooled
   d. contraction when cooled

120. Your confidence measure problem 119

121. The number of vibrations per second of a sound is know as its
   a. pitch
   b. frequency
   c. loudness
   d. tone

122. Your confidence measure problem 120

123. The type of circuit in which it is possible for one branch not to operate without affecting the rest of the circuit is called
a. in parallel
b. in series
c. a fluorescent
d. a short circuit

124. Your confidence rating for problem 123

125. A machine consisting of a bar which can rotate around a fulcrum is a
a. wheel and axle
b. lever
c. cylinder
d. screw

126. Your confidence rating for problem 125

127. Which of the following statements best describes your current estimate of your knowledge of the areas of the physical sciences that are appropriate for elementary school
a. I am very poorly prepared
b. I know a little about some of the areas of the physical sciences
c. I know something about most of the areas of the physical sciences
d. I have a pretty good knowledge of most of the areas of the physical sciences
e. I feel very well prepared

AREA III The Chemical Sciences
(includes: atomic structure, chemical changes, acids and bases energy, and other related subjects)

128. Which of the following statements best describes your knowledge of the areas of the chemical sciences that are appropriate for elementary school
a. I am very poorly prepared
b. I know a little about some of the areas of the chemical sciences
c. I know something about most of the areas of the chemical sciences

129. A form of matter which has a definite volume but no definite shape is a
a. gas
b. liquid
c. solid
d. suspension

130. Your confidence measure for problem 129

131. Of the following, the one that is an element is
   a. water
   b. hydrogen
   c. carbon dioxide
   d. salt

132. Your confidence measure for problem 131

133. The bubbling in soft drinks or sodas is due to
   a. air dissolved in the liquid
   b. carbon dioxide dissolved in the liquid
   c. alcohol in the liquid
   d. sugar in the liquid

134. Your confidence measure for problem 133

135. A girl thrusts a glowing splint into a bottle containing a gas. If the splint bursts into flame, the gas in the bottle is
   a. steam
   b. oxygen
   c. carbon dioxide
   d. nitrogen

136. Your confidence measure for problem 135

137. An element present in all common fuels is
   a. carbon
   b. nitrogen
   c. phosphorus
   d. sulfur

138. Your confidence measure for problem 137

139. Oil or grease prevents steel from rusting because it
   a. keeps the air away from the metal
   b. keeps the light away from the metal
   c. keeps the metal warm
   d. makes the metal slippery

140. Your confidence measure for problem 139

141. Clorine is often used in water purification to
   a. clear muddy water
   b. kill some harmful bacteria
   c. serve as a soap
   d. soften hard water

142. Your confidence measure for problem 141

143. Of the following, the substances that conducts heat most rapidly is
   a. copper
   b. asbestos

c. glass
d. mica

144. Your confidence measure for problem 143

145. When salt is boiled in an open pan
a. neither the salt or water evaporates
b. only the salt evaporates
c. both the salt and water evaporates
d. only the water evaporates

146. Your confidence measure for problem 145

147. Water is composed of the elements
a. carbon and oxygen
b. carbon, hydrogen, and oxygen
c. hydrogen and oxygen
d. nitrogen and oxygen

148. Your confidence measure for problem 147

149. Which of the following statements best describes your current estimate of your knowledge of the areas of the chemical sciences that are appropriate for elementary school
a. I am very poorly prepared
b. I know a little about some of the areas of the chemical sciences
c. I know something about most of the areas of the chemical sciences
d. I feel very well prepared

150. Energy
a. can be created
b. can be destroyed
c. can always be stored
d. can be transformed from one form into another

151. Your confidence measure for problem 150

152. Of the following, the element that is naturally radioactive is
a. helium
b. radium
c. phosphorus
d. magnesium

153. Your confidence measure for problem 152

154. When matter is changed into matter having different properties, the type of change is called
   a. a physical change
   b. a chemical change
   c. an electrical change
   d. an atomic change

155. Your confidence measure for problem 154

156. A common substance containing an acid is
   a. baking soda
   b. flour
   c. soap flakes
   d. vinegar

157. Your confidence measure for problem 156

158. Oxidation takes place during the process of
   a. burning
   b. melting
   c. absorption
   d. evaporation

159. Your confidence measure for problem 158

160. To seperate water into its elements, it is necessary to
   a. add salt and then boil the solution rapidly
   b. add sulfuric acid to the water slowly
   c. boil the water rapidly
   d. pass an electric current through the water

161. Your confidence measure for problem 160

162. The type of energy transformation that takes place in the storage battery of a car is
   a. heat to mechanical
   b. mechanical to electrical
   c. chemical to electrical
   d. electrical to mechanical

163. Your confidence measure for problem 162

164. A metal that is liquid at room temperature is
   a. copper
   b. lead
   c. mercury
   d. zinc

165. Your confidence measure for problem 164

166. A substance that cause blue litmus paper to turn red is
   a. alcohol
   b. an acid
   c. a base
   d. a salt

167. Your confidence measure for problem 166

168. The poisonous and odorless gas given off during the operation of an automobile is
   a. carbon dioxide
   b. carbon monoxide
   c. nitrogen
   d. oxygen

169. Your confidence measure for problem 168

170. Which of the following statements best describes your current estimate of your knowledge of the areas of the chemical sciences that are appropriate for the elementary school
   a. I am very poorly prepared
   b. I know a little about some of the areas of the chemical sciences
   c. I know something about most of the areas of the chemical sciences
   d. I have a pretty good knowledge of most of the areas of the chemical sciences
   e. I feel very well prepared

AREA IV The Earth Sciences
(includes: the atmosphere, weather, soil and conservation, the crust of the earth, and the solar system and universe)

171. Which of the following statements best describes your knowledge of the areas of the earth sciences that are appropriate for elementary school
   a. I am very poorly prepared
   b. I know a little about some of the areas of the earth sciences
   c. I know something about most of the areas of the earth sciences
   d. I have a pretty good knowledge of most of the areas of the earth sciences
   e. I feel very well prepared

172. Air is a
   a. single gas
   b. compound of two gases
   c. compound of three gases
   d. mixture of several gases

173. Your confidence measure for problem 172

174. The percentage of water vapor in the air is called
   a. barometic pressure
   b. relative humidity
   c. saturation
   d. water level

175. Your confidence measure for problem 174

176. The sun is a
   a. star
   b. planet
   c. satellite
   d. galaxy

177. Your confidence measure for problem 176

178. The inclination of the earth's axis is one of the causes of
   a. night and day
   b. seasonal changes
   c. tides
   d. hurricanes

179. Your confidence measure for problem 178

180. Stars are seen because they
   a. are larger than the earth
   b. are many light-years away
   c. give off their own light and heat
   d. reflect sunlight

181. Your confidence measure for problem 180

182. Sandstone is a sedimentary rock because it is
   a. formed by heat
   b. formed by water
   c. made in desert areas
   d. made of sand

183. Your confidence measure for problem 182

184. The breaking down of the rocks of the of the earth's surface is known as
   a. stratification
   b. weathering
   c. evaporation
   d. decay

185. Your confidence measure for problem 184

186. Decaying plant and animal matter is usually found in
   a. topsoil
   b. sand
   c. subsoil
   d. clay

187. Your confidence measure for problem 186

188. Water that sinks into the soil is known as
   a. the water table
   b. ground water
   c. a solution
   d. a river

189. Your confidence measure for problem 188

190. A group of stars forming a fixed pattern in the sky is called a
   a. galaxy
   b. constellation
   c. meteor
   d. comet

191. Your confidence measure for problem 190

192. Which of the following statements best describes your current estimate of your knowledge of the areas of the earth sciences that are appropriate for elementary school
   a. I am very poorly prepared
   b. I know a little about some of the areas of the earth sciences
   c. I know something about most of the areas of the earth sciences
   d. I have a pretty good knowledge of most of the areas of the earth sciences
   e. I feel very well prepared

193. The most abundant gas in air is
   a. carbon dioxide
   b. nitrogen
   c. oxygen
   d. water vapor

194. Your confidence measure for problem 193

195. By decreasing the air pressure, air can be made to move from
   a. a low pressure region to a high pressure region
   b. a high pressure region to a low pressure region
   c. a high pressure region to another high pressure region
   d. a region of low pressure to a region have the same pressure

196. Your confidence measure for problem 195

197. Winds are caused by
   a. ocean currents
   b. the motions of the earth
   c. the waving of the branches of trees
   d. the unequal heating of the earth's surface

198. Your confidence meaure for problem 197

199. The path of the earth around the sun is
   a. slightly elloptical
   b. circular
   c. square
   d. triangular

200. Your confidence meaure for problem 199

201. The distance of a place north or south of the equator is called its
   a. position
   b. longitude
   c. latitude
   d. meridan

202. Your confidence measure for problem 201

203. A light-year is a unit of
   a. speed
   b. time
   c. distance
   d. volume

204. Your confidence measure for problem 203

205. The clay need for making chinaware is obtained from the mineral
   a. sand
   b. copper
   c. quartz
   d. feldspar

206. Your confidence measure for problem 205

207. Fossils are found chiefly in
   a. igneous rock
   b. lava
   c. metamorphic rock
   d. sedimentary rock

208. Your confidence measure for problem 207

209. The most important single agent that wears away rock and changes the earth's surface is
   a. glacial action
   b. wind
   c. running water
   d. frost action

210. Your confidence measure for problem 209

211. In swampland there is
   a. no water table
   b. a low water table
   c. a high water table
   d. no rainfall

212. Your confidence measure for problem 211

213. Which of the following statements best describes your current estimate of your knowledge of the areas of the earth sciences that are appropriate for elementary school
   a. I am very poorly prepared
   b. I know a little about some of the areas of the earth sciences
   c. I know something about most of the areas of the earth sciences
   d. I have a pretty good knowledge of most of the areas of the earth sciences
   e. I feel very well prepared

214. Which of the following statements best describes your knowledge of the general science content that is appropriate for elementary school
   a. I am very poorly prepared
   b. I know a little about some of the areas of science
   c. I know something about most of the areas of science
   d. I have a prettty good knowledge of most of the areas of science
   e. I feel very well prepared

APPENDIX D

OMNIBUS PERSONALITY INVENTORY--

BRIEF SCALE DESCRIPTIONS

OMNIBUS PERSONALITY INVENTORY --- BRIEF SCALE DESCRIPTIONS

Thinking Introversion (TI): Persons scoring high on this measure are characterized by a liking for reflective thought and academic activities. They express interests in a broad range of ideas and in a variety of areas, such as literature, art and philosophy. Their thinking is less dominated by objective conditions and generally accepted ideas than that of thinking extroverts (low scorers). Most extroverts show a preference for overt action and tend to evaluate ideas on the basis of their practical, immediate application.

Theoretical Orientation (TO): This scale measures an interest in, or orientation to, a more restricted range of ideas than is true of TI. High scorers are interested in science and in some scientific activities, including a preference for using the scientific method in thinking. They are generally logical, analytical, and critical in their approach to problems.

Estheticism (Es): High scorers endorse statements indicating diverse interests in, as well as an appreciation of, artistic matters and activities. The focus of their interests tends to extend beyond painting, sculpture and music and includes interests in literature and dramatics.

Complexity (Co): This measure reflects an experimental orientation rather than a fixed way of viewing and organizing phenomena. High scorers are tolerant of ambiguities and uncertainties; they are generally fond of novel situations and ideas. Most high scorers very much prefer to deal with diversity and complexity, as opposed to simplicity and structure, and are disposed to seek out and enjoy unusual ambiguous events and experiences.

Autonomy (Au): The characteristic measured is composed of non-authoritarian attitudes and a need for independence. High scorers are sufficiently independent of authority, as traditionally imposed through social institutions, that they oppose infringements on the rights of individuals. They are tolerant of viewpoints other than their own, and they are nonjudgmental, realistic, and intellectually liberal.

Religious Orientation (RO): High scorers are skeptical of conventional religious beliefs and practices and tend to reject most of them, especially those that are orthodox or fundamentalistic in nature. Persons scoring near or above the mean are manifesting a liberal view of religious beliefs, and low scorers tend to be conservative in general and rejecting of other view points. (The direction of scoring on this scale, with strong religious commitment indicated by low scores, was determined in part by the correlation between these items and the first four scales which together measure a general intellectual disposition.)

Social Extroversion (SE): This measure reflects a preferred style of relating to people in a social context. High scorers, displaying a strong interest in being with people, seek social activities and gain satisfaction from them. The social introvert (low scorers) tends to withdraw from social contacts and responsibilities.

Impulse Expression (IE): This scale assesses a general readiness to express impulses and to seek gratification either in conscious thought or in overt action. High scorers have an active imagination, value sensual reactions, and their thinking and behavior has pervasive overtones of feelings and fantasies.

Personal Integration (PI): The high scorer admits to few attitudes and behaviors that characterize anxious, disturbed or socially alienated persons. Low scorers on the other hand, may intentionally avoid others and often express hostility and aggressions. They also indicate feelings of loneliness, rejection, and isolation.

Anxiety Level (AL): High scorers deny that they have feelings or symptoms of anxiety and do not admit to being nervous or worried. Low scorers are generally tense and high-strung and often experience some difficulty adjusting in their social environment.

Altruism (Am): The high scorer is an affiliative person and trusting in his relations with others. He exhibits concern for the feelings and welfare of people he meets. Low scorers tend to be much less concerned about the welfare of others and often view people from an impersonal, distant perspective.

Practical Outlook (PO): The high scorer on this measure is interested in practical, applied activities and tends to value material possessions and concrete accomplishments. The criterion most often used to evaluate ideas and things is one of immediate utility. Authoritarianism, conservatism and nonintellectual interests are very frequent personality components of persons scoring above the average.

Masculinity-Femininity (MF): This scale assesses some of the differences in attitudes and interests between college men and women. High scorers (masculine) deny interests in esthetic matters and they admit to few adjustment problems, feelings of anxiety, or personal inadequacies. They also tend to be somewhat less socially inclined than low scorers and more interested in scientific matters. Low scorers (feminine), besides stronger esthetic and social inclinations, also admit to greater sensitivity and emotionality.

Response Bias (RB): This measure represents an approach to assessing the students test-taking attitude. High scorers are responding to this measure in a manner similar to a group of students who were explicitly asked to make a good impression by their responses to these items. Low scorers, on the contrary, may be trying to make a bad impression.

LIFE SCIENCE CRITERION

220. Which of the following features can always be used to seperate plants and animals (13-1)
   a. only plants produce their own food
   b. only plants have a cell wall
   c. only animals are mobil
   d. none of the above

221. Confidence Rating problem 220

222. Which of the following is the primary role of bacteria in raising good crops (14-2)
   a. bacteria are used as food by the plants
   b. bacteria aerate the soil
   c. bacteria break down dead plants and animals
   d. none of the above

223. Confidence Rating problem 222

224. An example of a protective adaptation in an animal is (15-3)
   a. nocturnal habits
   b. number
   c. mimicry
   d. all of the above

225. Confidence Rating problem 224

226. Which of the following is an example of a caste in the honey bee hive (17-2)
   a. worker
   b. drone
   c. queen
   d. all of the above

227. Confidence Rating problem 226

228. A plant that completes its cycle in two years is called (19-2)
   a. a perennial
   b. a biennial
   c. an annual
   d. none of the above

229. Confidence Rating problem 228

230. Which of the following features do scientists use to determine whether something is alive (13-2)
   a. the type of elements it contains
   b. the ability to reproduce its own kind
   c. the ability to grow
   d. two of the above

231. Confidence Rating problem 230

232. Animals or plants that live on or inside another organism, both partners benefiting, are called (14-5)
   a. symbionts
   b. mutuals
   c. parasites
   d. commensials

233. Confidence Rating problem 232

234. A stage in incomplete metamorphosis, and not complete metamorphosis, is the (16-3)
   a. nymph
   b. pupa
   c. larva
   d. egg

235. Confidence Rating problem 234

236. Which of the following best explains how birds of the same species know to build the same type of nest (18-2)
   a. trial-and-error behavior
   b. conscious thought
   c. instinctive behavior
   d. none of the above

237. Confidence Rating problem 236

238. Man's distinct features that seperates him from other animals is (21-2)
   a. his superior strength
   b. his superior instinctive behavior
   c. his highly developed hands
   d. his superior mental ability

239. Confidence Rating problem 238

240. Which of the following do scientists believe is important in the conduction of water from the roots to the leaves of trees (13-3)
   a. contracting fibers
   b. transpiration
   c. cohesion of water molecules
   d. two of the above

APPENDIX E

CRITERION MEASURE

241. Confidence Rating problem 240

242. Which of the following is true of lower animals (15-1)
   a. they typically provide parental care to their offspring
   b. they typically produce a large number of eggs
   c. typically a large number of their offspring reach maturity
   d. none of the above are true

243. Confidence Rating problem 242

244. The caterpillar represents which stage of metamorphosis (16-4)
   a. larva
   b. egg
   c. adult
   d. pupa

245. Confidence Rating problem 244

246. Which of the following is not true about a spider web (18-3)
   a. it is a product of instinctive behavior
   b. it serves as a food getting device
   c. each individual spider produces a unique web
   d. it serves as a home for the spider

247. Confidence Rating problem 246

248. A feature that seperates mammals from other vertebrates is (21-1)
   a. a backbone
   b. a closed circulatory system
   c. being warm blooded
   d. a diaphram that seperates the heart and lungs

249. Confidence Rating problem 248

250. During photosynthesis plants produce (13-4)
   a. carbon dioxide and sugar
   b. oxygen and starch
   c. carbon dioxide and starch
   d. oxygen and sugar

251. Confidence Rating problem 250

252. A soil that is rich in nutrients, but is closely packed is (14-3)
   a. sandy soil
   b. loam
   c. clay
   d. black soil

253. Confidence Rating problem 252

254. Which of the following is a major way plants are classified (16-2)
   a. by the color of their seeds
   b. by the size of their leaves
   c. by the number of seed leaves
   d. by the shape of the seeds

255. Confidence Rating problem 254

256. Which of the following is not true about galls (18-4)
   a. each type of gall infests only one particular part of a plant
   b. the type of organism causing the gall may be determined by the shape of the gall
   c. the gall is caused by the spores of plants
   d. all of the above are true

257. Confidence Rating problem 256

258. Which of the following occurs when an animal hibernates (20-1)
   a. its breathing rate slows down
   b. its circulation of blood slows down
   c. the animal slowly burns excess fat
   d. all of the above

259. Confidence Rating problem 258

260. Which of the following statements best describes the balance of nature on the earth today (14-6)
   a. a balanced system with almost no change
   b. an overall balanced system with great changes over short periods of time
   c. an overall balanced system that is ever changing to a moderate degree
   d. none of the above statements are accurate

261. Confidence Rating problem 260

262. Which of the following is used by scientists to classify plants and animals (13-5)
   a. structure
   b. habitate
   c. development
   d. two of the above

263. Confidence Rating problem 262

264. Scientists believe that colonial animals perform their job in the social organization by (17-1)
   a. trial-and-error behavior
   b. conscious thought
   c. instinctive behavior
   d. none of the above

265. Confidence Rating problem 264

266. The dropping of leaves by a tree in the winter (19-1)
   a. helps conserve food
   b. helps conserve water
   c. helps conserve minerals
   d. two of the above

267. Confidence Rating problem 266

268. Which of the following is not an adaptation of birds for flight (20-2)
   a. strong solid bones
   b. strong pliable feathers
   c. rapid oxidation (burning of food)
   d. good digestive and breathing systems

269. Confidence Rating problem 268

270. Which of the following is a true statement about spontaneous generation (13-6)
   a. it is an accepted principle of modern biology
   b. it is a belief that living things may cone from the non-living
   c. it is concerned with the relationship of plants and animals to their environment
   d. none of the above are true

271. Confidence Rating problem 270

272. Which of the following statements is most accurate concerning bacteria and insects (14-4)
   a. most bacteria and insects are harmful to man
   b. most bacteria are beneficial, while most insects are harmful to man
   c. most bacteria are harmful, while most insects are beneficial to man
   d. bacteria and insects are both harmful and helpful to man

273. Confidence Rating problem 272

274. A major difference between social and colonial animals is (17-4)
   a. that only colonial animals have castes
   b. that colonial animals usually occur among lower animals
   c. social animals form a much looser organization than do colonial animals
   d. none of the above are a major difference

275. Confidence Rating problem 274

276. An example of a protective adaptation in a plant is (15-2)
   a. bad tasting fruit
   b. stickers on the branches
   c. hard external covering
   d. all of the above

277. Confidence Rating problem 276

278. The bird nest is primarily an adaptation for (18-1)
   a. the protection of the adult bird
   b. keeping the adult bird warm
   c. rearing young
   d. none of the above

279. Confidence Rating problem 276

280. A condition that is required for a seed to germinate is (16-1)
   a. carbon dioxide
   b. light
   c. oxygen
   d. soil

281. Confidence Rating problem 280

282. Which of the following is a characteristic of social insects that gives them an advantage in survival (17-3)
   a. better care and feeding of young
   b. better methods of food production
   c division of labor
   d. all of the above

283. Confidence Rating problem 282

284. Which of the following is true about the theory of natural selection (15-4)
   a. intelligence and conscious thought is an important factor
   b. most accidental changes in offspring make them more likely to survive
   c. a new type of organism of the same species may force the old type out of existence
   d. none of the above

285. Confidence Rating problem 284

220. If an astronaut traveled to a planet like Jupiter, which is larger than the earth, his weight would (7-1)
   a. be less than on the earth
   b. be the same as on the earth
   c. be more than on the earth
   d. be impossible to predict given only this information

221. Confidence Rating problem 220

222. Most modern geologists believe (8-1)
   a. that all the continents were covered by water at one time
   b. that the average density of the rocks that form the continents is higher than those forming the ocean basin
   c. two of the above are true
   d. none of the above are true

223. Confidence Rating problem 222

224. Drifts and currents in the ocena are caused by (8-5)
   a. the pull of the moon and sun
   b. the prevailing winds
   c. the unequal heating of the ocean
   d. none of the above

225. Confidence Rating problem 224

226. The rise of mammals occurred during the (10-4)
   a. Cenozoic era
   b. Precambrian era
   c. Mesozoic era
   d. Paleozoic era

227. Confidence Rating problem 226

228. An example of a climate condition is (12-4)
   a. the day's weather
   b. the average rainfall during the year in a region
   c. the average temperature during a day in a region
   d. the number of inches of rain that fell in a region in one week

229. Confidence Rating problem 228

230. A motor (23-4)
   a. changes mechanical energy into electrical energy
   b. changes electrical energy into mechanical energy
   c. has the opposite function to that of a generator
   d. two of the above are true

231. Confidence Rating problem 230

232. The loudness of a sound depends on (24-4)
   a. the energy of the vibrating body
   b. the pitch of the sound
   c. the number of overtones it contains
   d. two of the above are true

233. Confidence Rating problem 232

234. Isostasy is (8-2)
   a. a type of rock formation
   b. a theory concerning the formation of glaciers
   c. a hypothesis explaining the balance in the earth's crust
   d. none of the above are true

235. Confidence Rating problem 234

236. Which of the following are both weathering agents (9-3)
   a. mechanical action and gravity
   b. gravity and water
   c. glaciers and chemical action
   d. gravity and mechanical action

237. Confidence Rating problem 236

238. Which of the following is not a method by which chemists identify chemicals (11-4)
   a. by the solutions they form
   b. by their odor
   c. by the chemical reations they produce
   d. all of the above are correct methods

239. Confidence Rating problem 238

240. A simple machine (22-3)
   a. may change energy into a more convenient form for man
   b. may give us more lifting power
   c. can not give us more work or energy than we start with
   d. all of the above are true

241. Confidence Rating problem 240

242. The Doppler Effect predicts that (24-3)
   a. high frequency sound will travel farther than low frequency sound
   b. sound will become softer as it spreads out
   c. the pitch of sound will increase when it comes from an approaching source
   d. sound will travel through a vacuum

243. Confidence Rating problem 242

244. Which of the following is not true about the sun (7-2)
   a. the sun is a star
   b. the sun produces light by combustion
   c. the sun is made of hot liquids
   d. two of the above

245. Confidence Rating problem 244

246. Which of the following is true about the water table (8-6)
   a. it's level is constant throughout the seasons of the year
   b. it appears at about the same depth throughout the United States
   c. it represents the level of the ground water
   d. all of the above are true

247. Confidence Rating problem 246

248. Which of the following statements is not true about the formation of coal (10-3)
   a. heat and pressure were required
   b. it was formed from the remains of coal-producing animals
   c. the climate was warm and humid when it was formed
   d. it formed during the Pennsylvanian Period

249. Confidence Rating problem 248

250. The law of conservation of energy (22-1)
   a. describes conditions under which matter may be created
   b. describes conditions under which matter may be destroyed
   c. describes how electrical energy may be converted into mechanical energy

251. Confidence Rating problem 250

252. The theory that explains the characteristics of light best is the (24-2)
   a. quantum theory
   b. wave theory
   c. corpuscular theory
   d. vibration theory

253. Confidence Rating problem 252

254. Which of the following best describes why we still have snow at the north pole during the summer (7-3)
   a. due to the prevailing cold winds
   b. due to the fact that sunlight strikes the earth at an angle at the poles
   c. due to the fact that there is not warm ocean currents in the area
   d. none of the above are true

255. Confidence Rating problem 254

256. Fossils are usually found in (8-4)
   a. igneous rock
   b. metamorphic rock
   c. sedimentary rock
   d. both igneous and sedimentary rock

257. Confidence Rating problem 256

258. A continental glacier (9-4)
   a. forms on the tops and sides of high mountains
   b. is also called an ice sheet
   c. is smaller than a valley glacier
   d. two of the above are true

259. Confidence Rating problem 258

260. The nitrogen in our atmosphere (12-1)
   a. is the most common element
   b. causes substances to burn
   c. is not important to life on the earth
   d. two of the above are true

261. Confidence Rating problem 260

262. If we did not have friction on the earth (22-4)
   a. life would be more enjoyable
   b. things would not wear out
   c. we could still have electric light
   d. all of the above are true

263. Confidence Rating problem 262

264. Which of the following does not help explain how a glass prism may form a spectrum of colored light (24-1)
   a. light is bent when it leaves air and enters another transparent substance
   b. white light contains all the colors in the spectrum
   c. different colors of light are bent in different directions by the glass prism

265. Confidence Rating problem 264

266. At which of the following locations on the earth would the stars not change their position very much from night to night (7-4)
   a. north pole
   b. equator
   c. northern latitudes
   d. southern latitudes

267. Confidence Rating problem 266

268. An atomic particle that has a positive charge is the (11-1)
   a. proton
   b. electron
   c. neutron
   d. two of the above

269. Confidence Rating problem 268

270. The north pole of a compass (23-1)
   a. points towards the earth's north pole
   b. must have opposite polarity to the north pole of the earth
   c. is often called the north-seeking pole
   d. all of the above are true

271. Confidence Rating problem 270

272. Which of the following statements about eclipses is true (7-5)
   a. a lunar eclipse is caused by the moon casting a shadow on the earth
   b. an eclipse on the earth usally casts a large shadow
   c. partial eclipses are rarer than complete ones on the earth

273. Confidence Rating problem 272

274. Which of the following is the best definition of a mineral (8-3)
   a. one or more elements combined chemically
   b. a substance containing two or more types of rocks
   c. a mixture of several chemical compounds
   d. none of the above are a good definition

275. Confidence Rating problem 274

276. Which of the following is true about earthquakes (9-1)
   a. they occur along a fault plane
   b. they occur when rocks reach their elastic limit
   c. during an earthquake rock walls slip and come to rest in a new position
   d. all of the above are true

277. Confidence Rating problem 276

278. Which of the following is not an example of a fossil (10-1)
   a. casts of plants and animals
   b. petrified wood
   c. prints made by plants or animals
   d. all of the above are examples of fossils

279. Confidence Rating problem 278

280. A molecule (11-2)
   a. can also be an element
   b. can also be a compound
   c. is the smallest particle into which a substance can be divided and still be that substance

281. Confidence Rating problem 280

282. A high pressure front (12-2)
   a. moves toward regions of low pressure
   b. is usually associated with stormy weather
   c. can be detected by a barometer
   d. two of the above are true

283. Confidence Rating problem 282

284. Which of the following is true about a rocket (22-2)
   a. it requires air from the atmosphere for it's propulsion
   b. it gets it's lifting power from the air
   c. it's operation conforms to one of Newton's laws
   d. all of the above are true

285. Confidence Rating problem 284

286. Permanent magnets (23-2)
   a. are usually made of soft iron
   b. are easier to magnitize than are temporary magnets
   c. hold their magnetism longer than do temporary magnets
   d. all of the above are true

287. Confidence Rating problem 286

288. Which of the following statements is not true about the earth's tides (7-6)
   a. they go through a monthly cycle
   b. the sun has more influence on the tides than does the moon
   c. the highest tide of the year is called the spring tide
   d. the lowest tide of the year is called the neap tide

289. Confidence Rating problem 288

290. Which of the following best describes the difference between magma and lava (9-2)
   a. magma is solid lava
   b. lava contains many gases, while magma is free of most gases
   c. lava is solid magma
   d. magma contains many gases, while lava is free of most gases

291. Confidence Rating problem 290

292. Geologic time is divided in which of the following ways (10-2)
   a. ears, eons, epochs, and periods
   b. periods, eons, eras, and epochs
   c. periods, epochs, eons, and eras
   d. eons, eras, periods, and epochs

293. Confidence Rating problem 292

294. A chemical change occurs when (11-3)
   a. water evaporates
   b. gasoline is burned
   c. water is frozen
   d. sugar is dissolved in water

295. Confidence Rating problem 294

296. Relative humidity (12-3)
   a. is simple the number of pints of water per cubic yard of air
   b. is expressed in a percentage
   c. increases as the temperature increases
   d. all of the above are true

297. Confidence Rating problem 296

298. Which of the following is ture about current electricity (23-3)
   a. it may be positively or negatively charged
   b. it is another name for static electricity
   c. it requires a conductor
   d. none of the above are true

299. Confidence Rating problem 298

APPENDIX F

STUDENT ATTITUDE TOWARD INSTRUCTIONAL GAMES QUESTIONNAIRE

STUDENT ATTITUDE TOWARD INSTRUCTIONAL GAMES

This is not a test of information; therefore, there is no one "right" answer to a question. We are interested in your opinion on each of the statements below. Your opinions will be strictly confidential. Do not hesitate to put down exactly how you feel about each item. We are seeking information, not compliments; please be frank.

NAME:_____ DATE_____

NAME OF COURSE_____

CIRCLE THE RESPONSE THAT MOST NEARLY REPRESENTS YOUR REACTION TO EACH OF THE STATEMENTS BELOW:

1. As a change of pace from usual classroom learning the game was welcome.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

2. I felt insecure playing the game.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

3. All of the students enjoyed this game.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

4. I would rather learn the material some other way thar. games.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

5. I would choose to play the game rather than participate in a group discussion on the topic.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

6. Games are fun to me.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

7. The time spent playing this game was completely wasted.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

8. There is a definite need for instructional games.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

9. Games make me feel uncomfortable and irritable.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

10. I felt at ease playing the game.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

11. My liking for games outweighs my disliking.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

12. The value of games is overestimated by some people.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agre	Strongly Agree

13. When I hear the word "game," I have a feeling of dislike.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

14. I would prefer playing this game to playing a non-instructional game that I personally enjoy such as bridge, chess or poker.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

15. The material covered by this game was uninteresting.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

16. In preference to lectures on the same subject, I would like to try more learning games.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

17. I approach games with a feeling of hesitation, resulting from fear of doing poorly.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

18. The feeling I have toward games is a good feeling.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

19. The game was stimulating.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

20. Only a few of the students enjoy this game.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

21. I feel a definite positive reaction to games.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

22. Games make me feel lost.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

23. Universities should use class time for games.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

24. Games are something I've never enjoyed.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

25. I was under a strain while playing the game.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

26. The game I just played was interesting.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

27. I don't like to play games.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

28. Instructional games should be considered a valuable part of this course.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

29. I was inspired by this game to make full use of my capabilities.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

30. The experience was not particularly beneficial.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

31. I'll remember what I learned in the game.

: Strongly Disagree	: Disagree	: Uncertain	: Agree	: Strongly Agree

32. In view of the amount of time involved, I feel too little was accomplished.

: Strongly Disagree	: Disagree	: Uncertain	: Agree	: Strongly Agree

33. This game increased my knowledge in this subject area.

: Strongly Disagree	: Disagree	: Uncertain	: Agree	: Strongly Agree

34. I found it difficult to concentrate on learning anything.

: Strongly Disagree	: Disagree	: Uncertain	: Agree	: Strongly Agree

35. As I got into the game, I learned painlessly.

: Strongly Disagree	: Disagree	: Uncertain	: Agree	: Strongly Agree

36. I would have learned more from a lecture.

: Strongly Disagree	: Disagree	: Uncertain	: Agree	: Strongly Agree

37. My mind went blank and I was unable to think whe. playing the game.

: Strongly Disagree	: Disagree	: Uncertain	: Agree	: Strongly Agree

38. After graduation, the information obtained from this game will be ~~available~~ available

: Strongly Disagree	: Disagree	: Uncertain	: Agree	: Strongly Agree

39. I don't know any more than when I started.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

40. I learn more from games than from individual study.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

41. I learned while playing but it was hard work.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

42. This was a confusing game.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

43. I learn more from games than from group discussion.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

44. The students don't remember anything they learned in the game.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

45. While playing the game I had moments of great insights.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

46. Playing games such as this one is the most effective way to learn new concepts.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

47. I felt the role I played was very unnatural.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

48. I like games that are challenging.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

49. This game has no influence upon the students.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

50. I played because I had to.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

51. I felt like getting involved in game playing.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

52. I didn't apply myself.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

53. I wasn't satisfied with how I played the game.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

54. Games do not provide the necessary motivation to learn the subject.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

55. I'll play better next time.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

56. This game is not worth the time and effort to play it.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

57. I was not conscious of time passing.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

58. I dislike people who play half-heartedly.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

59. I'd cut class if I thought we were going to play again.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

60. I felt like learning the concepts so I could play the game better.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

61. I didn't know what I was doing during the game.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

62. I worked hard playing the game.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

63. I was aware of game and implications but did not enjoy time spent.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

64. When the game got difficult, I gave up.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

65. I wasn't bothered about learning anything while I was playing the game.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

66. I felt everyone fitted their roles well.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

67. This game didn't suit the situation.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

68. It is important to play well.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

69. I found myself just trying to get through the game rather than trying to learn.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

70. It was difficult to become motivated within the game context.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

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